Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Riparian Instream Flow Study
Study Plan Section 8.6

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants

June 2014

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	**Definition**
AEA	Alaska Energy Authority
DBH	Diameter at Breast Height; approximately 1.4 meters from ground
DD	Degree Day
DY_{20}	Day of Year when plants have released 20 percent of seeds
DY_{80}	Day of Year when plants have released 80 percent of seeds
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
GW/SW	Groundwater/Surface Water
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HEC-GEORAS	A GIS extension that prepares GIS data for import into HEC-RAS and generation of GIS data from HEC-RAS output
ILP	Integrated Licensing Process
ITU	Integrated Terrain Unit
ISR	Initial Study Report
LAI	Leaf Area Index
PRM	Project River Mile; determined during 2012-2013 studies
Project	Susitna-Watana Hydroelectric Project
QC	Quality Control
Riparian IFS	Riparian Instream Flow Study
RIMS	Resonant Ionization Mass Spectrometer
RIP-ET	Riparian – Evapotranspiration, a package used with MODFLOW groundwater modeling program.
RM	River Mile; determined from 1980s study
RMSE	Relative mean-squared error
RPD	Riparian Process Domain

Abbreviation	Definition
RSP	Revised Study Plan
SPD	Study Plan Determination
TDP	Thermal Dissipation Probe
USFWS	U.S. Fish and Wildlife Service
VPD	Vapor Pressure Deficit

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP), which included 58 individual study plans (AEA 2012). Included within the RSP was the Riparian Instream Flow Study (Section 8.6). This section focuses on the methods for assessing the effects of the proposed Project and its operations on the floodplain plant communities in the Susitna River basin.

On April 1, 2013, FERC issued its study determination (April 1 SPD) for RSP Section 8.6, approving the study with modifications. In its April 1 SPD, FERC recommended the following:

> *Seedling Establishment*
>
> - *We recommend that the study plan be modified to require AEA to sample seedling establishment following the initial spring peak flows (e.g., July) and again in September in 2013 and 2014.*
>
> *Adequacy of MODFLOW and Xylem Water Isotopic Sampling to Establish Groundwater/Hydroperiod Relationships*
>
> - *We recommend that AEA consult with the TWG on the sampling design for collecting plant xylem water; and file no later than June 30, 2013, the following:*
>   1) *A detailed description of the sampling sites, frequency, and schedule.*
>   2) *Documentation of consultation with the TWG, including how its comments were addressed.*
>
> *Soil Profile Sampling*
>
> - *We recommend that the study plan be modified to specify that sediment grain size measurements would be based on samples taken at soil horizons, rather than at equal depth increments.*
>
> *Vegetation Response Curves*
>
> - *We recommend that AEA do so in consultation with the riparian technical workgroup. Methods of analysis should be reported in the initial and updated study reports.*

Consultation on the interrelated Riparian Vegetation Study Downstream of the Proposed Susitna-Watana Dam (Riparian Vegetation Study 11.6), Riparian Instream Flow Study (Riparian IFS Study 8.5), and Groundwater Study (Study 7.5) study plans was accomplished with TWG representatives in two meetings, held on April 23, 2013 and June 6, 2013. Licensing participants were provided the opportunity to address technical details and comments and concerns regarding the study's approaches and methods.

The Riparian Instream Flow, Groundwater, and Riparian Vegetation Studies FERC Determination Response Technical Memorandum (Riparian/GW TM) addresses FERC's April 1 SPD request concerning sampling design for collecting plant xylem water (R2 Resource Consultants et al. 2013). The Riparian/GW TM was filed with FERC on July 1, 2013.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule" (18 CFR 5.15(c)(1)). This Initial Study Report (ISR) on the Riparian Instream Flow Study has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP and as modified by FERC's April 1 SPD and Riparian/GW TM (collectively referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The goal of the Riparian Instream Flow Study (hereafter Riparian IFS) is to provide a quantitative, spatially explicit model to predict potential impacts to downstream floodplain vegetation from Project operational flow modification of natural Susitna River flow, sediment, and ice regimes. To meet this goal, AEA is applying a physical and vegetation process modeling approach. First, existing Susitna River groundwater and surface water (GW/SW) flow, sediment, and ice regimes are being measured and modeled relative to floodplain plant community establishment, recruitment, and maintenance requirements. Second, predictive models are being developed to assess potential Project operational impacts to floodplain plant communities and provide operational guidance to minimize these impacts. Third, the predictive models are being applied spatially in a Geographic Information System (GIS) to the riparian vegetation map produced by the Riparian Vegetation Study (Study 11.6) to produce a series of maps of predicted changes under alternative operational flow scenarios.

Seven Riparian IFS objectives were established in RSP Section 8.6.1:

1. Synthesize historic physical and biological data for Susitna River floodplain vegetation, including 1980s studies, studies of hydro project impacts on downstream floodplain plant communities, and studies of un-impacted floodplain plant community successional processes.
2. Delineate sections of the Susitna River with similar environments, vegetation, and riparian processes, termed *riparian process domains* (RPDs), and select representative areas within each riparian process domain, termed *Focus Areas*, for use in detailed 2013–2014 field studies.
3. Characterize seed dispersal and seedling establishment groundwater and surface water hydroregime requirements. Develop a predictive model of potential Project operational impacts to seed dispersal and seedling establishment.
4. Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation. Develop a predictive model of potential Project operational

impacts to ice process regimes and dominant floodplain vegetation establishment and recruitment.

5. Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils, and vegetation. Develop a predictive model of Project operations changes to erosion and sediment deposition patterns and associated floodplain vegetation.
6. Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime. Develop a predictive model to assess potential changes to natural hydroregime and potential floodplain vegetation.
7. Develop floodplain vegetation study synthesis, scaling of Focus Areas to riparian process domains, and Project operations effects modeling**.**

3. STUDY AREA

As established in RSP Section 8.6.2, the study area includes the Susitna River active floodplain that would be affected by the operation of the Project downstream of the proposed Watana Dam (PRM 187.1). The active floodplain is the valley bottom flooded under the current climate. For the 2013 work, the lateral extent of the riparian vegetation study area was defined by the extent of the riverine physiographic region generated by the Susitna River. Riverine physiography includes (1) those areas of the valley bottom, including off-channel water bodies, that are directly influenced by regular (0–25 year) to irregular (25–100 year) overbank flooding; and (2) those areas of the valley bottom influenced indirectly by groundwater associated with the Susitna River. The riverine physiographic map has undergone review and refinement by the principal investigators leading the Riparian IFS, Riparian Vegetation Study (Study 11.6), and associated physical processes studies (Groundwater, Ice Processes, and Fluvial Geomorphology Modeling). Upon review of 2013 field data, the active floodplain map will be revised, as needed, and a final riverine physiography layer will be prepared for use as the lateral boundary of the Riparian IFS Study for subsequent study.

The longitudinal extent of the 2013 study area for the Riparian IFS Study has been defined in coordination with the Riparian Vegetation, Fluvial Geomorphology Modeling, and Groundwater Studies. The study area includes those riparian areas downstream of the Project dam site to a point at which the effects of altered stage and flow effects expected in the Susitna River would not be ecologically significant (i.e., the expected hydraulic alterations would be overridden by the input from other rivers and/or the effects of tidal fluctuations from Cook Inlet). Following the completion of the Open-water Flow Routing Model in Q1 2013, AEA, after receiving input from the TWG, extended the downstream extent of the study areas for the riparian studies, including the Riparian Vegetation Study, to PRM 29.9 (R2 2013b).

4. METHODS AND VARIANCES IN 2013

The Riparian IFS will develop a process-based model of riparian vegetation succession and dynamics driven by riverine hydrogeomorphic processes. The modeling approach uses geomorphic, hydraulic, ice process, and GW/SW interaction models coupled with riparian vegetation succession models based upon riparian vegetation surveys and previous Susitna River riparian forest research (Helm and Collins 1997). Objectives of the modeling approach are as follows:

1. Measure and model riparian vegetation physical process relationships under the natural flow, sediment, and ice regimes.
2. Model potential impacts to riparian vegetation resulting from Project operational changes to natural flow, sediment, and ice process regimes.
3. Provide guidance for Project operation scenarios to minimize potential riparian vegetation impacts.

The Riparian IFS methods section is presented in the following format addressing each of the seven Project components and objectives as they have been completed in 2013. First, each study component and its associated objectives are described. Second, study methods, with appropriate literature citations, are presented. Third, any variances from the Study Plan are presented. The Riparian IFS Project schedule and plans for completing the study are presented in Section 7.

4.1. Synthesize Historic Physical and Biological Data for Susitna River Floodplain Vegetation, Including 1980s Studies, Studies of Hydro Project Impacts on Downstream Floodplain Plant Communities, and Studies of Un-impacted Floodplain Plant Community Successional Processes (hereafter, Literature Review of Dam Effects on Downstream Vegetation)

The goal of this study is to critically review and synthesize historic Susitna River riparian vegetation studies within the context of physical process investigations conducted in the 1980s, including ice processes, sediment transport, GW/SW, and herbivory. Studies of downriver floodplain vegetation response to hydroregulation on other hydro projects (both North American and circumpolar) are being incorporated into the review to develop a current state-of-the-science analysis of potential Project operational flow effects to Susitna River riparian floodplain vegetation. Additionally, studies of un-impacted temperate and boreal floodplain plant community successional processes will be incorporated into the study as appropriate. Study objectives, methods, and expected results are summarized in Table 4.1-1.

The objectives of this study task are as follows:

1. Conduct a critical review of previous Susitna River 1980s floodplain vegetation studies.
2. Place potential Project operational effects within the context of studies from other hydroregulated rivers in North America.
3. Review, and include relevant findings of, current research concerning temperate and boreal floodplain forest succession and dynamics under natural flow regimes.

4.1.1. Methods

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.2.1).

A critical literature review of all appropriate Susitna River 1980s studies, historic and current hydro project floodplain effects studies, and temperate and boreal floodplain forest scientific literature is being developed in coordination with the Fluvial Geomorphology Modeling literature review. The synthesis of findings will focus on elements relevant to evaluating potential Project operation effects on downstream floodplain vegetation. An annotated, searchable bibliography will be developed in coordination with the critical literature review.

4.1.2. Variances from Study Plan

Completion of the literature review was scheduled for Q4 2013 and is now scheduled for 2014. Because of the close linkage between the riparian and geomorphology studies, the review will now be a combined literature review for both studies. However, this variance will actually benefit the Project in that the literature review will be more comprehensive and combine information for both riparian and fluvial geomorphology into one document.

4.2. Focus Area Selection−Riparian Process Domain Delineation

Floodplain plant communities within northern mountain river corridors are dynamic as channel and ice processes annually disturb floodplain vegetation. The characteristic patchwork of floodplain vegetation composition, structure, and age reflects patterns of disturbance across the floodplain landscape (Naiman et al. 1998). Vegetation disturbance can be defined as those processes that remove or otherwise impact plant communities and soils, often setting the system back to an earlier successional state. Floodplain vegetation disturbance types found within the study area include channel migration (erosion and depositional processes), ice processes (shearing impacts, flooding, freezing, and sediment deposition), herbivory (beaver, moose, and hare), wind, and, to an infrequent extent, fire. Floodplain disturbance regimes (type, magnitude, frequency, duration, and timing) vary systematically throughout river networks and, therefore, their geographic distribution may be mapped (Montgomery 1999).

Process domains define specific geographic areas in which various geomorphic processes govern habitat attributes and dynamics (Montgomery 1999). Within the mountain river network, temporal and spatial variability of channel, ice, and sediment disturbance processes can be classified and mapped, allowing characterization of specific riparian process domains with similar suites of floodplain disturbance types. The riparian process domain approach is hierarchical in structure, allowing for river network stratified sampling to statistically describe elements and processes within each process domain. Riparian IFS Study sites, including those located within Focus Areas, were selected to capture the variability in floodplain vegetation, and geomorphic terrains, within each riparian process domain. The number of riparian Focus Areas necessary to capture process domain variability was determined through a spatially constrained cluster analysis. The hierarchical stratification of the Susitna River basin into riparian process domains facilitates both representative sampling and the ”scaling-up” of Focus Area modeling results to the larger study area.

The issue of pseudoreplication (Hurlbert 1984), and the number of adequate sample sites necessary to perform robust statistical analyses, is addressed in the hierarchical riparian process domain sampling design and integration of the Riparian Vegetation Study design. Focus Area sites have been selected to be representative of specific riparian process domains and their channel/floodplain characteristics (ice process domains, channel planform, channel slope, channel confinement). Focus Area physical and vegetation processes will be modeled and floodplain vegetation-flow response relationships statistically described in probabilistic models (Rains et al. 2004). The Riparian Vegetation Study (see ISR Study 11.6 for vegetation statistical sampling protocols) is designed to provide study area-wide representative sample replicates of floodplain vegetation, soils, and alluvial terrain relationships. Furthermore, the surface water flood regime for the study area will be modeled, and mapped, providing flow regime plant community relationship analysis replicates throughout the greater study area, in addition to those modeled at each Focus Area. The riparian process domain and study area-wide sampling of the Riparian Vegetation Study are specifically designed to address the question of pseudoreplication. Study objectives, methods, and expected results are summarized in Table 4.2-1.

The objectives of the Focus Area selection and riparian process domain delineation are as follows:

1. Develop a riparian process domain stratification of the study area.
2. Select Focus Areas representative of each riparian process domain for physical process and vegetation survey sampling and modeling.

4.2.1. Methods

AEA implemented the methods as described in the Study Plan with no variances.

Preliminary riparian process domain delineation and riparian Focus Area selection was an iterative process. This iterative process is described in the steps below. First, in 2012, the Middle River Segment (PRM 102.4-187.1) was delineated into large-scale geomorphic river segments with relatively homogeneous characteristics, including channel width, entrenchment, ratio, sinuosity, slope, geology/bed material, single/multiple channel, braiding index, and hydrology (inflow from major tributaries). Ten candidate Focus Areas were defined as important for the Fish and Aquatics IFS (FA-IFS) Study (see ISR Study 8.5). From these ten initial candidate Focus Areas, a total of five Focus Areas for further riparian study were ultimately selected.

Second, prior to selection of any riparian Focus Areas in 2012, the Riparian-IFS lead independently examined the entire Middle River Segment from the proposed Watana Dam site to the Three Rivers Confluence and selected eight sections 1 to 3 miles in length that captured, upon first examination, variability in channel confinement (active channel/floodplain width) and channel planform. These eight candidate sections were ultimately found to correspond to eight of the ten Focus Areas selected in the FA-IFS Study 8.5 and in the R2 Resource Consultants Technical Memorandum (2013). The overlap in the independently selected riparian floodplain and FA-IFS Focus Areas is not surprising because they represent the most geomorphically complex reaches in the Middle River Segment in terms of channel and floodplain complexity.

Third, questions remained, however, whether the eight Focus Areas identified for riparian analysis were representative of vegetation types and abundance within the entire Middle River Segment, and whether all eight Focus Areas were necessary to fully capture variability in plant community characteristics across the study area. To statistically evaluate the representativeness of the riparian Focus Area selections, a detailed quantitative analysis was completed that involved the determination of riparian process domains and vegetation typing within the entire Middle River Segment. This analysis allowed for comparisons of vegetation types and abundance both between Focus Areas and areas outside of Focus Areas within individual riparian process domains. Additionally, two of the Focus Areas were not included in the riparian sections: FA-141 (Indian River) and (FA-151) Portage Creek; these sites contained little, if any, floodplain area and therefore were not relevant to the Riparian IFS study objectives. These two sites were therefore removed during the initial riparian Focus Area determination process.

Fourth, preliminary delineation of riparian process domains was completed using a spatially constrained cluster analysis (Legendre and Legendre 2012) of geologic and geomorphic data gathered in ArcGIS from geo-rectified aerial imagery and LiDAR digital elevation map (2011 Matsu Ortho Imagery at 1:8000 scale, http://matsu.gina.alaska.edu/wms/imagery). In the Middle River Segment, a total of 340 transects was placed and aligned perpendicular to the valley bottom axis at 1/4-mile intervals from the proposed Watana Dam site (PRM 187.1) to Three Rivers Confluence (PRM 102.4). At each transect, geomorphic variables were measured: channel slope, confinement ratio (defined as the active channel width divided by the total floodplain width), and channel types. Channel types assigned for this analysis included main channel, side channel, split main channel, and braided main channel. Determinations of active channel vs. off-channel geomorphic features were consistent with definitions developed in the Fluvial Geomorphology Modeling Study (ISR Study 6.6) (Tetra Tech 2013). Vegetation data were not included in this third step of the analysis by design. The geologic and geomorphic type classification data were used in constrained agglomerative clustering, a spatially constrained cluster analysis process, using Legendre's package of functions for *R* (R Development Core Team 2011), *const.clust (*http://adn.biol.umontreal.ca/~numericalecology/Rcode/) to group study area channel reaches and segments into riparian process domains. The agglomerative clustering algorithm begins with each transect as its own cluster, then iteratively joins the adjacent transects that are most similar (smallest *distance*). The multivariate *distance* between two transects was defined using the distance metric formalized by Gower (1971) and recommended by Legendre (P. Legendre, Professor, Departement de sciences biologiques, Universite de Montreal, personal communication, February 25, 2013). For continuous variables and ordered factors, the univariate distance is the scaled difference $|Xi - Xj|$/max (difference). The multivariate distance is simply the average of these distances for the three variables.

The clustering algorithm creates as many clusters as the user defines. For this study, the number of clusters was defined as the minimum cross-validation residual error method as recommended by Legendre in the *const.clust* package. Cross-validation is a resampling technique that estimates the ratio of variation that is not explained by the cluster partition to the total variation in the transect measurements. The cross-validation routine selects the best number of clusters to minimize this unexplained variance.

Fifth, floodplain vegetation data were collected along the digitized transects established in the third step described above. Each transect was segmented and vegetation was classified according to Viereck Level III plant community type (Viereck et al. 1992) by the Riparian Vegetation Study (Study 11.6). Lineal distances were computed for each discrete vegetation community. Transect data describes the spatial distribution and abundance of plant communities along the entire length of the Middle River Segment.

Finally, Viereck Level III vegetation types and type abundance were summarized for (1) each of the riparian process domains (Devils Canyon was excluded); and 2) each of the eight Focus Areas. The Focus Areas in each riparian process domain were then examined as to their vegetation types, relative abundances, and representativeness relative to the entire riparian process domain. Final 2013 Focus Area selection was described in the March 1, 2013 Focus Area Technical Memorandum (R2 Resource Consultants [R2] 2013) and riparian vegetation study analysis (Appendix A). A subset of five of the preliminary eight candidate Focus Areas was selected that together capture variability of plant communities present in the study area.

4.2.2. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season. Methods were refined from the RSP to the ISR as described in Section 4.2.1 above.

4.3. Characterize Seed Dispersal and Seedling Establishment Groundwater and Surface Water Hydroregime Requirements. Develop Predictive Model of Potential Project Operational Impacts to Seedling Establishment (hereafter, Seed Dispersal and Seedling Establishment)

Floodplain plant seed dispersal and seedling establishment are critical processes in floodplain plant community succession that may be affected by hydro project operations (Braatne et al. 1996; Cooper et al. 1999; Rood et al. 2003). In this study dominant woody species seed dispersal and seedling establishment hydrologic requirements are being determined through field surveys and groundwater and surface water interaction measurement and modeling. The study has two subtasks: (1) seed dispersal, hydrology, and local Susitna River valley climate synchrony study; and (2) seedling establishment and recruitment study.

4.3.1. Synchrony of Seed Dispersal, Hydrology, and Local Susitna River Valley Climate

Susitna River pioneer riparian tree and shrub species in the family *Salicaceae,* balsam poplar (*Populus balsamifera* and *Populus balsamifera* ssp. *trichocarpa,* and any hybrids of these; also commonly referred to as cottonwood) and willows (*Salix* spp.), are adapted to seasonal snowmelt-driven spring peak flows in terms of timing of seed dispersal, newly deposited mineral colonization substrates, and concordant near-surface floodplain groundwater conditions, all necessary conditions for poplar and willow seedling establishment and recruitment (Figure 4.3-1; Braatne et al. 1996; Mahoney and Rood 1998; Mouw et al. 2012). Project operations would result in a reduction of June/July peak flows and might result in a reduction of associated floodplain groundwater elevations necessary for dispersal and establishment of balsam poplar and willow trees and shrubs. The timing of snowmelt spring flows, and of tree and shrub seedling release and dispersal, is critical to successful establishment and maintenance of arid and temperate riparian floodplain forests (Figure 4.3-2; Braatne et al. 1996; Mahoney and Rood 1998). The "recruitment box model," an empirical model that captures balsam poplar and willow seed dispersal, flow response, and recruitment requirements, has been successfully demonstrated on arid, semi-arid and temperate region rivers throughout North America (Figure 4.3-2) (Mahoney and Rood 1998; Rood et al. 2003). The model characterizes seasonal flow pattern, associated river stage (elevation), and flow ramping necessary for successful balsam poplar and willow seedling establishment (Figure 4.3-1 and Figure 4.3-2). A recruitment box model for balsam poplar and select willow species for the Susitna River will be developed using 2 years of data to characterize the relationship between seed dispersal, timing, flow regime and Susitna Valley climate. Study objectives, methods, and expected results are summarized in Table 4.3-1.

Objectives of the seed dispersal, hydrology, and climate synchrony study are as follows:

1. Measure balsam poplar and select willow species seed dispersal timing.
2. Measure and model local Susitna River valley climate and associated seasonal peak flows relative to balsam poplar and willow seed dispersal.
3. Develop a recruitment box model of seed dispersal timing, river flow regime, and balsam poplar and willow seed dispersal and establishment.

4.3.1.1. Methods

AEA implemented the methods as described in the Study Plan with no variances.

To evaluate synchrony of balsam poplar and select willow species [feltleaf willow (*Salix alaxensis*), Barclay's willow (*S. barclayi*), and Sitka willow (*S. sitchensis*)] seed release, and Susitna River natural flow regime, the following tasks were begun in 2013 and will continue in Q2 to Q3 of the next study year: (1) a 2-year survey of seed release of balsam poplar and select willow species; (2) development of a 'degree-day' climate model for the onset of seed release relative to local temperature conditions using methods developed by Stella et al. (2006); and (3) analysis of historic climate and Susitna River flow regime relationships. The results of the study will identify flow regime timing conditions necessary to support riparian balsam poplar and willow establishment on the Susitna River.

Four floodplain sites near existing meteorological stations in the Middle and Lower Susitna River Segments (Figure 4.3-3) were selected for balsam poplar and willow species seed release surveys. At each site, 6 dominant female balsam poplar trees and 6 to 12 willows were surveyed weekly during the months of June and July. In the AEA approved Study Plan, seed release observations were predicted to continue through the first 2 weeks of August; however, in 2013, the peak seed release occurred earlier than expected and few seeds remained by the end of July. Thus seed release observations were discontinued at the end of July.

Balsam poplar seed release was measured during each survey by summing 20-second counts of open catkins from the top, middle, and bottom portion of each tree according to methods developed by Stella et al. (2006). Due to the shrub growth form of willows an untimed count of open catkins for each entire shrub was performed. Weekly surveys were halted once no open catkins were visible on trees and shrubs or the count remained unchanged for several weeks following peak seed release. Floodplain riparian plant community characteristics were sampled for each floodplain seed dispersal site using vegetation sampling techniques outlined in the Riparian Vegetation Study (see ISR Study 11.6, Section 4). Initial tree data and seed release timing data collected in 2013 were analyzed using protocols developed by Stella et al. (2006). At all field sites, local air temperature measurements were collected from adjacent weather monitoring stations (Figure 4.3-3). If no weather monitoring station had been established in the vicinity of the seed release study site, temperature loggers (HOBO U23 Pro v2; Onset, Bourne, MA) were installed inside a solar radiation shield approximately 1 meter (3.3 feet) above the ground surface. A preliminary degree-day model using seed release observations and continuous temperature records from the monitoring stations was developed using the first year of data (Stella et al. 2006). This model will be re-run with data from 2 years of observations. A recruitment box model (Figure 4.3-2); Mahoney and Rood 1998; Rood et al. 2003) will be developed to evaluate the potential effects of Project operational flow scenarios on balsam poplar and willow establishment.

4.3.1.2. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season. Methods were refined from the RSP to the ISR as described in Section 4.3.1 above.

4.3.2. Seedling Establishment and Recruitment

Riparian vegetation in mountain river networks is adapted to a dynamic physical disturbance regime, including flooding, summer desiccation, erosion, sediment burial, ice shearing and freezing, wind, herbivory and, infrequently, fire (Naiman et al. 1998). Seedling establishment, survival, and recruitment are critical phases in the development of floodplain plant communities within this dynamic physical environment (Walker and Chapin 1986; Walker et al. 1986; Karrenberg et al. 2002; Mouw et al. 2009, 2012; Rood et al. 2007). The goal of the seedling establishment and recruitment study is to identify, measure, and model potential impacts of Project operational changes to the groundwater, surface water, sediment, and ice regimes, and to assess the effects on seedling establishment and recruitment within the active channel margin/floodplain environment.

Identifying the spatial locations, and groundwater, surface water, and sediment requirements under which new cohorts of dominant riparian plant seedlings establish, survive, and recruit on the Susitna River floodplain is a critical element in evaluating potential floodplain vegetation effects of Project operational alterations of the natural flow and sediment regimes. River ice seedling interactions, an additional critical physical disturbance factor, will be investigated in the Ice Process Modeling Study (see Section 4.4.2).

Seedling recruitment on the Susitna River floodplain occurs not only on new flood-deposited sediments along channel and floodplain margins—the primary sites of balsam poplar, willow, thinleaf alder (*Alnus incana* ssp. *tenuifolia),* and mountain alder (*Alnus viridis* ssp. *crispa*) colonization—but also on sediment deposits within the developing and mature floodplain forest (Helm and Collins 1997). Helm and Collins (1997) noted that within the Susitna River floodplain forest, white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) seedlings were found to establish, and recruit, on mineral soils associated with both floodplain surface sediment deposits, ice-influenced sediment deposits, and tree windthrow mound soils. Also, white spruce and paper birch seedlings were observed growing on mounds of gravel and sand apparently pushed onto the floodplain interior by ice flows.

Study objectives, methods, and expected results are summarized in Table 4.3-2. Objectives of the seedling establishment study are as follows:

1. Map and characterize seedling establishment and recruitment of dominant woody riparian species, balsam poplar, white spruce, paper birch, thinleaf and mountain alder, feltleaf willow, and Barclay's willow along lateral channel margins and floodplain surfaces. As recommended by FERC (April 1 SPD), seedlings were assessed following the initial spring peak flows (e.g., July) and again in September in 2013. The RSP required seedling surveys to be conducted throughout the Focus Area, and Riparian Vegetation Study sites, active channel margins, and floodplains. Upon field observations, it was determined that current Focus Areas, collectively, were adequate to meet objectives of the seedling establishment study. Therefore, seedling surveys occurred within Focus Areas along lateral channel margins and floodplain surfaces.
2. Use a stratified random sampling approach, with variable plot sizes (Mueller-Dombois and Ellenburg 1974), to sample mapped seedling polygons.
3. Identify seedlings to species, and measure seedling heights and density.
4. Describe and measure seedling site soil characteristics associated with seedling establishment and recruitment (see Section 8.6.3.7 for methods).
5. Measure and model GW/SW hydroregimes associated with seedling establishment and recruitment. Measure seedling xylem water source through isotopic analysis (see Section 8.6.3.6 for methods).
6. Investigate ice process seedling site interactions through empirical observations and ice process modeling.
7. Develop a probabilistic model of seedling hydrologic, sediment, and ice regime processes.

4.3.2.1. Methods

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.3.2.2).

Following on-the-ground observations and reconnaissance surveys conducted throughout the study area in Q2 2013, sampling methods were refined to characterize seedling establishment and recruitment patterns for dominant riparian woody species, including balsam poplar, white spruce, paper birch, thinleaf and mountain alder, feltleaf willow, and other willow species.

Seedling reconnaissance surveys were completed by helicopter and on foot in Focus Areas FA-104 (Whiskers Slough), FA-113 (Oxbow 1), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), and FA-144 (Slough 21) to identify patterns of seedling distribution. Locations of dense seedling populations were mapped with a hand-held GPS unit. Seedlings of balsam poplar and willow species were found in large first-year cohort (seedlings having the same year of establishment) populations along lateral margins of mid-channel islands and occasionally along lateral margins of the main and side channels. White spruce and paper birch seedlings were found to be establishing on tree tip-up mounds (pit and mound topography) throughout older floodplain surfaces as observed by Helm and Collins (1997) and described in Harza-Ebasco (1985). White spruce seedlings were also found within younger seral stages on mid-channel islands.

Three survey methods were selected to characterize these widely divergent establishment and recruitment patterns: (1) first year (0+) balsam poplar and willow establishment; (2) clonal balsam poplar and willow recruitment; and (3) white spruce and birch establishment. Methods for each study are described below.

In the Study Plan, seedlings were defined as plants with stems less than 1 meter (3.3 feet) in height. However, following reconnaissance surveys, it became clear that poplar and willow establishing on lateral margins of mid-channel islands are subject to frequent disturbance by ice. Given the degree of ice shearing disturbance and sediment burial of stems, height appears not necessarily to be directly related to age of the stem. These trees and shrubs, due to annual ice shearing and sediment deposition, may remain less than 1 meter (3.3 feet) in height for many years and are not true seedlings. Moreover, ice laydown and burial may result in stems that are less than 1 meter in height but are actually clones associated with much older buried “parent” stems. It is difficult to differentiate clonal vs. sexual recruitment with non-destructive sampling methods. Similarly, as birch and spruce often establish below a full canopy, it may take one or more decades to exceed 1 meter (3.3 feet) in height. Therefore, the first year (0+) balsam poplar and willow establishment study was restricted to documenting current cohort of seedlings less than 1 year old. The spruce and birch establishment and recruitment study documented distribution of all age classes of spruce and birch regardless of height.

Results of seedling and soils and microtopography characterizations will be used to assess seedling groundwater, surface water, and ice regime relationships using 1-D/2-D, MODFLOW and ice process modeling results from the Groundwater, Fluvial Geomorphology Modeling, and Ice Processes studies (Studies 7.5, 6.6, and 7.6, respectively). A probabilistic model of seedling occurrence and GW/SW, sediment, and ice regimes will be developed using techniques and methods described in Franz and Bazzaz (1977), Rains et al. (2004), Henszey et al. (2004), Baird and Maddock (2005), and Maddock et al. (2012).

The results of Focus Area modeling will be scaled-up to the riparian process domains using spatially explicit GIS models as described in Section 4.2.

4.3.2.1.1. First Year (0+) Balsam Poplar and Willow Seedling Establishment

As described above, areas of dense populations of seedlings were first mapped along lateral channel and floodplain margins within six Focus Areas and seedling patches were stratified into five floodplain terrain types (island head, island tail, slough, main channel, side channel). Sample sites were randomly selected for further study. Second, 0.25-square-meter (2.7-square-foot) quadrats were laid out at 1-meter (3.3-foot) intervals along randomly located transects along a baseline established parallel to the channel. Two to three transect locations were randomly located extending normal to the channel from lowest extent of seedling occurrence (typically the edge of water) to full vegetative canopy cover in adjacent floodplain forest or shrub community.

Each transect was permanently marked with a rebar pin and buried magnetic marker for annual repeat measurements. Third, within each plot, poplar and willow first-year germinants/seedlings were counted to estimate abundance and density. In addition to counting target woody seedlings, all herbaceous plants within the plots were identified to species. Aerial percent cover and stem heights for tree or shrub seedlings were measured. At each 0.25-square-meter (2.7-square-foot) quadrat the following data were collected:

- Sediment texture was recorded as percent cover of quadrat gravel or cobble vs. percent cover by sand or silt.
- Depth to gravel/cobble layer was measured using a 2-meter (6.6 ft) tile probe (AMS, Inc.).
- Elevation of each quadrat was surveyed with a level. An intermediate benchmark was set that was later surveyed with survey-grade RTK and tied into the Project datum.
- Soils were collected to a depth of 10 centimeters (3.9 inches) at each seedling plot with seedlings present in the September 2013 survey. Soil particle size will be measured using standard hydrometer analysis (Soil Survey Staff 2009).

Seedlings were collected in September 2013 at a sub-sample of Focus Area seedling sites for xylem isotopic analysis to identify source of water (see Section 4.5). Excavated seedling root lengths were measured. In addition, shallow groundwater wells were installed in pairs along a sub-sample of seedling transects. Shallow groundwater wells consisted of perforated 2-inch-diameter pipe installed as deep as possible below the surface and extending into the cobble subsurface. Fifteen wells were installed along transects at depths ranging from 1.6 to 4.6 feet below the floodplain surface. Well-water level depths were measured relative to the floodplain elevation and adjacent surface water levels. Water level measurements were conducted at least three times in Q3 2013.

As recommended by the FERC (April 1 SPD), first year (0+) seedling establishment sampling was completed following the initial spring peak flows in late July and early August 2013, and seedling presence sampling was repeated in early-mid September 2013. Year 2 monitoring will occur in late July and September during the next year of study.

4.3.2.1.2. White Spruce and Paper Birch Establishment

White spruce and paper birch recruitment was characterized along 8-meter-wide belt transects established on mid-channel islands in 2013. At each surveyed island, two transects were placed randomly along a baseline normal to the channel at the island head. Transects were extended the entire length of the island parallel to the channel. Location of the start and end points of each transect was collected with a hand-held GPS unit capable of sub-meter accuracy. Diameter at breast height (DBH) and height of each spruce tree within the 8-meter-wide (26.25 ft) belt transect were recorded. Additional white spruce and paper birch transects will be sampled in both lateral floodplain and mid-channel island locations on older floodplain surfaces.

To characterize age structure of white spruce on each sampled island, six to ten spruce seedlings, saplings, and/or trees were selected randomly and sampled using standard dendrochronologic techniques for tree and shrub sampling and growth ring measurements (Fritts 1976) as described in Section 4.5.1. At each white spruce either collected or cored for age determination, depth of sediment above the root collar and depth to gravel/cobble was measured with a tile probe. Additionally, soil sediment samples were taken to a depth of 20 centimeters (7.9 inches) with a 5-centimeter (2-inch) diameter soil corer (AMS). Soil sediment texture was described, and buried organic horizon depths measured, using standard NRCS methods.

Because paper birch rarely establish on mid-channel island floodplains, white spruce was the primary focus of the seedling surveys study in 2013. Additional transects will be established across the lateral floodplain in the next study year using similar methods to quantify floodplain and terrace spruce and birch recruitment within riparian Focus Areas.

4.3.2.2. Variances from Study Plan

AEA implemented the methods as described in the Study Plan with the exception of the variance explained below. Methods were refined from the RSP to the ISR as described in Section 4.3.2 above.

In the Study Plan, seedlings were defined as plants with stems less than 1 meter (3.3 ft) in height. However, following reconnaissance surveys, it became clear that poplar and willow establishing on lateral margins of mid-channel islands are subject to frequent disturbance by ice. Given the degree of ice shearing disturbance and sediment burial of stems, height appears not necessarily to be directly related to age of the stem. These trees and shrubs, due to annual ice shearing and sediment deposition, may remain less than 1 meter (3.3 ft) in height for many years and are not true seedlings. Moreover, ice laydown and burial may result in stems that are less than 1 meter in height but are actually clones associated with much older buried “parent” stems. It is difficult to differentiate clonal vs. sexual recruitment with non-destructive sampling methods. Similarly, as birch and spruce often establish below a full canopy, it may take one or more decades to exceed 1 meter (3.3 ft) in height. Therefore, the first year (0+) balsam poplar and willow establishment study was restricted to documenting current cohort of seedlings less than 1 year old. The spruce and birch establishment and recruitment study documented distribution of all age classes of spruce and birch regardless of height.

This change in methodology is a clarification of study methods that was determined based on on-the-ground observations and site-specific conditions that were not understood prior to the 2013 field season. To characterize poplar and willow clonal establishment, a clonal reproduction study for balsam poplar and willow will be conducted in identified and mapped high frequency ice disturbance zones. This study is a cross-over with the ice processes study element (Section 4.4) as it addresses both poplar and willow establishment processes and ice effects on these processes. Fieldwork for this study will be completed in the next study year using belt transect quadrats. Balsam poplar and willow less than 1 meter (3.3 ft) in height will be excavated to determine presence or absence of clonal connection to a larger buried parent stem. Height above the floodplain surface and depth of burial will be measured.

4.4. Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation. Develop predictive model of potential Project operational impacts to ice processes and dominant floodplain vegetation establishment and recruitment (hereafter, River Ice Effects on Floodplain Vegetation)

Although the role of fluvial disturbance (erosion and sediment deposition) in the development of floodplain vegetation has been well investigated (Naiman et al. 1998; Rood et al. 2007), the role of river ice processes has seen little study (Engstrom et al. 2011; Prowse and Beltaos 2002; Prowse and Culp 2003; Rood et al. 2007). The effects of river ice disturbance of floodplain vegetation have been observed in the Susitna River, and reported anecdotally, in Helm and Collins (1997). The 2012 Riparian Botanical Survey team observed extensive evidence of ice disturbance to floodplain trees, and soils, in the form of tree ice-scars, mechanically-disturbed soil stratigraphy, and floodplain gravel deposits throughout the Middle and Lower Susitna River surveys (Figure 4.4-1, Figure 4.4-2, and Figure 4.4-3).

Impacts of ice-related processes to riparian habitat typically occur during break-up when ice scours channel and floodplain surfaces (Prowse and Culp 2003). During break-up, ice accumulation in meander bends can create ice dams elevating backwater surfaces, forcing meltwater to bypass the bend and scour a new meander cutoff and generating new side channels (Prowse and Culp 2003). Elevated backwater, resulting from ice dams, may also float ice blocks onto and through vegetated floodplain surfaces, causing mechanical shearing effects, including tree ice-scarring and abrasion, removal of floodplain vegetation, shearing disturbance of floodplain soils, and burial of floodplain vegetation by sediment deposits (Engstrom et al. 2011; Rood et al. 2007; Prowse and Culp 2003).

4.4.1. Empirical Studies of River Ice and Floodplain Vegetation

AEA will rely on multiple lines of evidence to address the question of vegetation response to ice shearing influence on the Susitna River floodplain. First, ice vegetation impacts (tree ice-scars) will be observed, mapped, and aged (using dendrochronologic techniques), and gravel floodplain deposits will be mapped throughout the study area to develop a map of river ice floodplain vegetation interaction domains. Preliminary tree ice-scar mapping was begun during the 2012 Riparian Botanical Survey, and early October 2012 Focus Area reconnaissance. Mapping continued in Q2 and Q3 2013 and will be continued throughout the next riparian field season. Second, local residents will be interviewed concerning their knowledge of spatial locations of historic ice dams, years of significant ice occurrence, and other anecdotal historical information concerning ice on the Susitna River. From these two sources of information, a map will be created of Susitna River ice process floodplain vegetation effect domains. The ice process map will be used to (1) inform riparian process domain delineation (see Section 4.2); and (2) develop a floodplain vegetation study to compare floodplains affected by ice with those un-impacted by ice, similar to the approach of Engstrom et al. (2011).

Floodplain vegetation surveys were initiated in 2013. These surveys were designed to quantitatively measure (stratified random sampling of mapped floodplain vegetation ice shear process zones) and statistically describe and compare vegetation characteristics associated with floodplains experiencing ice shear events and floodplain vegetation without observed ice influence. The vegetation study design builds on the design and results of Engstrom et al. (2011) where they studied and assessed the effects of anchor ice on riparian vegetation. Engstrom and others found that species richness was higher at sites affected by anchor ice than at sites where anchor ice was absent, suggesting that ice disturbance plays a role in enhancing plant species richness (Engstrom et al. 2011).

The objective of the ice effects vegetation study is to quantitatively describe floodplain plant community composition, abundance, age, and spatial pattern to assess the role and degree of influence ice processes have on Susitna River floodplain vegetation. The results of the study will be used to assess how floodplain vegetation pattern and process may change with Project operation alterations of the natural ice process regime.

4.4.2. Ice Process Modeling

The Ice Process Study will develop and calibrate a dynamic thermal and ice processes model (see ISR 7.6). The ice process modeling study will provide the riparian ice vegetation study with estimated horizontal and vertical zones of ice formation, ice thickness, and floodplain impact zones. Model output will be used in conjunction with the tree ice-scar survey data to (1) empirically test model output with mapped riparian domains of ice floodplain vegetation interaction; and (2) model changes in locations and types of ice formation processes due to Project operations. Together, the mapped ice influence zones, empirical studies of vegetation/ice interactions, and modeling confirmation and prediction will be used to understand and evaluate the influence of Project operational flows on ice and floodplain vegetation interactions.

Study objectives, methods, and expected results are summarized in Table 4.4-1.

The objectives of the ice processes floodplain vegetation interaction and modeling study are as follows:

1. Develop an integrated model of ice process interactions with floodplain vegetation.
2. Conduct primary research to identify the effects of ice on floodplain vegetation within mapped Susitna River ice floodplain impact zones.
3. Provide Project operational guidance on potential effects of operations flow on ice formation and floodplain vegetation development.

4.4.3. Methods

AEA implemented the methods as described in the Study Plan with no variances.

The following methods are being used to quantify interactions and effects of ice on floodplain vegetation:

1. Mapping of ice floodplain vegetation interactions throughout the study area.
    a. Tree Ice-Scar Mapping

Tree ice-scars were surveyed in 2013 along the Middle River Segment of the Susitna River (PRM 102–146) during September and early October. Mapping was conducted via jet boat using a Trimble 2008 GeoXH with a mounted external antenna and off-set laser (TruPulse 360 Laser). Boat survey protocol was to stop every 0.2 mile where the nearest tree with an ice-scar was surveyed. If no ice-scarred trees were visible, the floodplain surface elevation was surveyed. Tree ice-scar measurements included (1) height of tree ice-scar; (2) height of floodplain surface at the base of the tree; (3) height of floodplain above the water surface; and (4) horizontal location of the tree or floodplain surface. Ocular counts of the number of trees with visible ice-scars were made between each 0.2-mile stopping point while the boat traveled slowly along the shoreline. Channel reaches not accessible by jet boat (e.g., shallow water, rocky channel substrate) were mapped as inaccessible. All GPS location data were post-processed with differential corrections using Trimble software and mapped on aerial photographs.

b. Tree Ice-Scar Dendrochronology

Ice-scarred trees were sampled to determine the year of the ice-scarring event and to develop an ice/floodplain interaction chronology. Scarred trees were sampled with a 16-inch chainsaw for dendrochronologic analyses (Fritts 1976; Stoffel and Bollschweiler 2008). Tree wedges were cut into tree bole ice-scars (Figure 4.4-4). Additional ice-scarred tree measurements included (1) height of tree ice-scar; (2) height of floodplain surface at the base of the tree; (3) height of floodplain above the water surface; and (4) horizontal location of the tree or floodplain surface. Measurements were made with hand tape and surveyed from the jet boat using a Trimble 2008 GeoXH with mounted external antenna and TruPulse 360 Laser. Tree location GPS data were differentially corrected using Trimble software and mapped on aerial photographs.

Tree wedges will be sanded using 200-600-grade sandpaper and growth rings counted and measured using standard dendrochronologic techniques (Fritts 1976). All tree-wedge samples will be photographed for archival purposes.

2. Aerial (via helicopter) 2013 mapping of ice break-up observations of local, sub-reach scale, floodplain vegetation stand-scale ice disturbance effects. Analysis of floodplain disturbance from 2013 ice break-up events.
3. Interviews of local Susitna River residents concerning knowledge of ice-dam locations and ice process effects.
4. Comparative quantitative vegetation study of ice effects on identified ice floodplain impact and un-impacted zones. Methods will build on those presented in Engstrom et al. (2011).
5. Final ice vegetation field sampling methodology was developed in Q2, Q3 2013 as described above.
6. Integration of ice process modeling results with empirical ice vegetation mapping and ice vegetation interaction studies.

4.4.4. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season. Methods were refined from the RSP to the ISR as described in Section 4.4.1 above.

4.5. Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils, and vegetation. Develop a predictive model of Project operations changes to erosion and sediment deposition patterns and associated floodplain vegetation (hereafter, Floodplain Stratigraphy and Floodplain Development)

The dynamic of channel migration—sediment transport, floodplain erosion, and sediment depositional patterns—is a critical physical process directly affecting floodplain soil development and vegetation establishment and recruitment throughout alluvial segments of the river network (Richards et al. 2002). The life history strategies and establishment requirements of floodplain plant species are adapted to natural flow and sediment regimes (Braatne et al. 1996; Naiman et al. 1998; Karrenberg et al. 2002). As such, alterations of natural hydrologic and sediment regime seasonal timing, magnitude, frequency, and duration may have effects on plant species establishment, survival, and recruitment (Braatne et al. 1996). The goal of this study is to characterize the role of erosion and sediment deposition in evolution of floodplain planform, soil development, and trajectory of plant community succession, especially vegetation establishment stage. This study, in coordination with the Fluvial Geomorphology Modeling Study (see Study 6.6), investigates the geomorphic evolution of the Project area floodplain with an emphasis on floodplain sediment deposition, stratigraphy, soil development, and associated plant community succession. Historic sediment deposition rates will be measured throughout the study area river network and variations in floodplain forming processes will be assessed. Finally, a predictive model will be developed with the Fluvial Geomorphology Modeling Study (see Study 6.6) to assess Project operational effects on hydrologic and sediment regimes, and effects on soil and floodplain plant community development.

In a river that meanders through a wide valley, such as the Susitna River, erosion on one side of the channel will be balanced by deposition on the opposite bank as the river migrates laterally. Disturbance to riparian habitat on the eroding bank will be balanced by opportunities for recruitment on the point bar. This type of geomorphic process maintains the characteristic range of floodplain surface elevations and vegetation age classes contributing to the diversity of floodplain vegetation composition and structure (Naiman et al. 1998). The rate of channel migration may be impacted by Project operations, with secondary impacts on the riparian community. The Fluvial Geomorphology Modeling Study will assess Project alterations to downstream channel bed and floodplain surface elevations through sediment transport modeling and analyses. These potential changes will be provided to the Riparian IFS. Development of the study design, modeling, and methods has been coordinated closely with Fluvial Geomorphology Modeling Study (Study 6.6), Ice Processes Study (Study 7.6), and Riparian Vegetation Study (Study 11.6) study teams (Table 4.5-1).

Study objectives, methods, and expected results are summarized in Table 4.5-1.

The objectives of the study are as follows:

1. Measure the rates of channel migration, and floodplain vegetation disturbance or turnover, throughout the study area.
2. Measure the rates of sediment deposition, and floodplain development, throughout the study area.
3. Assess/model how Project operations will affect changes in the natural sediment regime, floodplain depositional patterns, and soil development throughout the study area.
4. Assess/model how Project operation induced changes in sediment transport and soil development will affect floodplain plant community succession.

4.5.1. Methods

AEA implemented the methods as described in the Study Plan with no variances.

The following methods are being used to characterize floodplain sediment and depositional processes.

1. Floodplain soils and stratigraphy were sampled throughout the study area at Integrated Terrain Unit (ITU) plots located using a stratified random approach (see ISR Study 11.6.; Section 4). At each ITU plot, soil pits were excavated to a depth of 60 centimeters and standard NRCS methods were used to describe soil profiles as described in the Riparian Vegetation ISR (Study 11.6.; ISR Section 4).
2. Thirteen sediment cores were collected during 2013 consisting of five cores from FA-104 (Whiskers Slough) and eight cores from FA-115 (Slough 6A) for sediment isotope geochronological analysis. The sediment sample sites at both Focus Areas were located at ITU plot floodplain locations along transects perpendicular to the river. Topographic transects and plot locations were surveyed using RTK GPS survey instrumentation and tied into the Project survey datum. Sediment cores were collected with a thin-walled soil probe for ^{210}Pb and ^{137}Cs analysis (AMS Inc.) that is 91 centimeters (35.8 inches) long with a diameter of 2.5 centimeters (1 inch). Recovery of sediment cores was generally excellent with the longest cores, typically 60–130 centimeters (23.6–51.2 inches) in length depending on depth to cobble/gravel refusal layer. In shorter cores, a hard sediment plug blocked the cutting edge of the probe, preventing further sediment entry.
3. Sediment core ^{210}Pb and ^{137}Cs laboratory geochronology analyses will be conducted using standard methods (Aalto 2003; Aalto et al. 2008). Per the FERC approved Study Plan, particle size analysis by horizon and every centimeter will be conducted. This provides detail at a finer resolution than would be achieved with analysis by horizon alone. Selected cores will be sectioned at 2-centimeter (0.8 in) intervals for both particle size and isotope analyses (Aalto et al. 2003; Aalto et al. 2008). Sediment isotope laboratory results from 2013 data will be used to evaluate sediment geochronology methods and to determine the sediment study design for the next year of study. This

existing methodology captures the horizon profile analysis recommended in the FERC Study Plan Determination.

4. Woody species were sampled and aged at each ITU sample plot to determine year of origin. Standard dendrochronologic techniques were applied for tree and shrub sampling and growth ring measurements (Fritts 1976). Details of these methods are described below.
5. In addition to collecting tree-core samples from representative trees and shrubs, plant community characteristics were described at each ITU sample plot per methods outlined in the Riparian Vegetation Study (ISR Study 11.6.; Section 4).

At each ITU plot, two to three trees and shrubs per species were sampled for age determination. Tree and shrub samples were taken with either an increment borer, or, for smaller diameter stems, by cutting the shrub or sapling stem and removing a stem section for laboratory analysis. Increment cores (two per tree) were collected from each tree. For each tree sampled, floodplain sediment was excavated to uncover the stem root collar and depth of sediment aggradation was measured for further age estimation. Woody species seedlings for each dominant species were excavated, heights measured, stems sectioned at the root collar, and annual rings measured under a dissecting microscope. A regression analysis will be conducted to assess the relationship between stem age and seedling height. The results will be used to add additional years to trees to account for height of core sample above the root collar.

Tree cores were taken as close to the ground surface as possible, generally 30 centimeters (11.8 cm) or less above ground surface. The total height of the tree core sample above the root collar was calculated and used to estimate additional years to estimate tree year of origin.

Increment cores were mounted on pieces of 1-inch-by-2-inch wood and sanded with variable grades of sandpaper following standard methods described in Fritts (1976). Ring width measurements will be made, and annual years counted, for both the tree cores and stump sections using a dissecting microscope. Individual trees will be cross-dated, if possible, using standard methods (Fritts 1976).

4.5.2. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season. Methods were refined from the RSP to the ISR as described in Section 4.5.1 above.

4.6. Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime. Develop a predictive model to assess potential Project operational changes to natural hydroregime and floodplain vegetation (hereafter, Riparian GW/SW Hydroregime)

4.6.1. Riparian GW/SW Hydroregime Overview

Water sources for the establishment and maintenance of floodplain vegetation include precipitation, groundwater, and surface water (Cooper et al. 1999; Rood et al. 2003). Identifying both floodplain plant water sources and the groundwater/surface water (GW/SW) hydroregime associated with critical riparian plant species life stages is necessary to (1) characterize natural floodplain vegetation establishment and hydrologic requirements for maintenance; and (2) evaluate effects of Project operations on these hydroregimes and associated plant communities.

The goal of the floodplain vegetation GW/SW interaction modeling effort is to statistically characterize the relationship between the natural floodplain groundwater and surface water hydroregime, and associated floodplain plant communities, and to use this model to evaluate Project operational effects on floodplain vegetation. This investigation will (1) characterize water sources of dominant floodplain woody plant species establishment and maintenance life stages through stable isotope analyses of precipitation, river water, groundwater, soil water, and xylem water; (2) develop a floodplain GW/SW model; and (3) develop floodplain vegetation-flow response models.

Regional and local groundwater flow systems are important to floodplain vegetation (Figure 4.6-1). Seasonal river stage fluctuations generate transient GW/SW interactions at a local scale under and adjacent to the river, including side channels, side sloughs, and upland sloughs (Figure 4.6-2). Developing conceptual models and numerical representations of the GW/SW interactions, coupled with important processes in the unsaturated zone, will help evaluate the natural variability in the Susitna River floodplains, and reveal how various Project operations could result in alterations of floodplain plant community types (Rains et al. 2004).

Riparian woody species establishment has been associated with surface water flooding, precipitation, and groundwater (Braatne et al. 1996; Cooper et al. 1999; Rood et al. 2003). Riparian floodplain vegetation maintenance relies on precipitation, surface water, and groundwater as water sources (Cooper et al. 1999; Rood et al. 2003; Henszey et al. 2004). Recent research has demonstrated that poplar species (genus *Populus*) are facultative phreatophytes, deep-rooted plants that extract their water from the saturated zone or capillary fringe of the saturated zone, and opportunistic (facultative) with respect to water source (Rood et al. 2011). Poplar species have been shown to develop a range of root system depths depending upon moisture availability. Shallow rooting systems typically develop in moist temperate climates and deeper root systems often develop in arid to sub-arid environments (Rood et al. 2011). Floodplain groundwater depths have also been demonstrated to control floodplain plant community composition, species richness, and structure (Henszey et al. 2004; Baird and Maddock 2005; Mouw et al. 2009). Project operations may alter flows of the Susitna River seasonally (higher flows in winter time and lower flows in summer) and daily (resulting from load following), which may affect floodplain shallow aquifer water elevations. The riparian GW/SW study is designed to measure and evaluate the relationship between riparian floodplain plant communities and the natural GW/SW hydroregime, and to assess the floodplain aquifer response to flow modifications resulting from Project operations. The results of this study will be scaled-up from the Focus Areas to their respective riparian process domains to provide a flow-response function for the entire study area.

Study objectives, methods, and expected results are summarized in Table 4.6-1.

The objectives of the riparian GW/SW study are to:

1. Determine the seasonal sources of water for dominant riparian plant species and major riparian plant community types.
2. Define the natural GW/SW hydroregimes associated with the dominant riparian plant species and plant community types.
3. Determine how floodplain shallow aquifer water levels respond to Project operations.
4. Determine whether and the extent to which changes in GW/SW resulting from Project operations will affect riparian plant community composition, abundance, spatial distribution, and structure.

4.6.2. Methods

AEA implemented the methods as described in the Study Plan with no variances.

4.6.2.1. Stable Isotope Analyses

The predominant water source utilized by dominant woody and herbaceous species found along the Susitna River will be directly determined from stable isotope analyses of groundwater, soil water, precipitation, and plant xylem water. Stable isotopes of hydrogen and oxygen will be assessed. Due to inherent properties of isotopes (Lajtha and Marshall 1994), many biogeochemical processes have a specific isotopic signature measured as the ratio of heavy to light isotopes (Dawson et al. 1993; Lajtha and Marshall 1994). The use of isotopes provides a minimally destructive method for measuring water acquisition by plants. Within the soil profile, there are naturally occurring gradients of isotopic abundance in soil water (Dawson et al. 1993). Because plants do not discriminate against heavy isotopes during water uptake, xylem water in non-transpiring plant tissues retains the isotopic signature of the water source from which it was derived (Flanagan and Ehleringer 1991). Thus, isotopic abundance in xylem sap corresponds to the range of isotopic composition of all water taken up by plant roots, and can determine the source of a plant’s water uptake (Dawson et al. 1993; Dawson et al. 2002).

In order to determine isotope signatures of available water sources, water samples were collected during 2013 for precipitation, groundwater, and adjacent river water. Precipitation samples for stable isotope analyses were collected at FA-104 (Whiskers Slough) and FA-128 (Slough 8A) with a custom-made oil-type collector following the design in Scholl (2006). Because water in a container open to the atmosphere immediately begins to change in isotopic composition due to evaporation and exchange with ambient vapor (Ingraham and Criss 1993), evaporation and exchange are minimized in the oil-type collector, which is designed to inhibit evaporation. Precipitation samples were collected in 20-milliliter plastic scintillation vials and kept frozen until isotope analysis could be completed. Samples will be filtered to remove any oil prior to analysis.

Groundwater samples were collected in September 2013 from linear transect arrays of groundwater wells placed at the Focus Areas (see ISR Study 7.5). Wells were purged three times prior to sample collection using a hand crank ballast pump to ensure fresh groundwater in the well (Cooper et al. 2003). Samples were pumped directly from the well to 20-milliliter plastic scintillation vials. River water samples were collected in flowing current. Groundwater and river water sample vials were filled completely to eliminate headspace above the water, sealed tightly with caps, and covered with parafilm to reduce the possibility of fractionation after samples were collected. Samples will be kept frozen until isotope analysis can be completed.

Plant water sampling was conducted within different canopy cover types along GW/SW transects. A minimum of eight samples was collected per species at every canopy cover type sampled within a Focus Area. Plant water samples were collected through a combination of branch clipping and increment bore samples. Small shrubs and herbaceous species were sampled by collecting branch clippings. Stable isotope analysis of deuterium (^{2}H) and oxygen (^{18}O) ratios will be conducted for dominant woody and herbaceous species using standard methods (Cooper et al. 1999; Flanagan and Ehleringer 1991; Dawson and Ehleringer 1991).

The isotope analysis can help determine the rooting depth at which plants uptake water. Xylem water has been demonstrated to reflect isotopic composition of the source water taken up by roots (Flanagan and Ehleringer 1991; Dawson and Ehleringer 1991). Shallow soil layers submitted to higher evaporative demands tend to be enriched in heavy isotopes relative to deeper soil water layers (Dawson et al. 1993). However, natural abundance typically does not allow the distinction of differences in rooting depth from 30 to 50 centimeters (LeRoux et al. 1995; Jackson 1999; Ludwig et al. 2004; Kulmatiski et al. 2006). In order to create a reliable evaporation profile, soil sampling was completed in 2013 in four locations repeated three times during the growing season (June, July, and September). Soil samples were collected in 30-centimeter increments from 0 to 150 centimeters using a 5.08-centimeter-by-30.48-centimeter (2-inch-by-12-inch) diameter steel split spoon soil sampler (AMS, American Falls, ID). Cores were divided out of the sampler into the following samples: 0-5, 5-10, 10-15, 15-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, and 100-150 centimeters. Samples were thoroughly mixed for each sampling interval. A 12-milliliter glass tube was filled approximately half full (6 milliliters) with soil from each sampling interval and frozen until samples could be analyzed. The rest of the sample will be retained for root biomass analysis, as described below.

4.6.2.2. Characterization of Rooting Depths

Information concerning the depth of the root zone of dominant floodplain plants is needed to accurately model groundwater, capillary fringe, and floodplain plant relationships. In 2013, the rooting depth of dominant floodplain plants were measured through (1) a riverbank survey to observe and measure depth profiles of recently exposed root systems following Rood et al.

(2011), and (2) collection of soil samples to determine root mass per unit area within the soil profile.

The riverbank root surveys were conducted between PRM 102 and PRM 144 to rapidly observe rooting profile of as many trees as possible. Rooting depth observations will be combined with observations from trench excavations completed in the next study year. When all observations are complete, root zone excavation and riverbank root zone survey data will be statistically summarized to provide individual plant species and plant community type root zone depth characterization for use in GW/SW modeling.

In Q2 – Q3 2013, soil samples were collected for quantification of root mass within the soil profile. Root samples were collected at different vegetation cover types across FA-104 (Whiskers Slough) and FA-128 (Slough 8A) in conjunction with plant and soil isotope samples. As described above, soil samples were taken using a 5.08-centimeter-by-30.48-centimeter (2-inch-by-12-inch) diameter steel split spoon soil sampler at the following depths: 0-5, 5-10, 10-15, 15-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, and 100-150 centimeters. Soil was washed away from roots and roots will be kept frozen until they can be processed (dried and weighed) in a laboratory to determine root biomass by depth.

To determine available moisture within the soil profile, soil water content was measured using content reflectometers at specific soil depths (Model CS650, Campbell Scientific, Inc., Logan UT). Soil water content sensors were installed at 5, 10, 20, 50, 110, and 200 centimeters and at 5, 10, 25, 44, 65, and 85 centimeters in depth at FA-104 (Whiskers Slough) and FA-128 (Slough 8A), respectively. The asymmetric levels were chosen to more accurately represent vertical variation in the rooting depths (Wilson et al. 2001).

4.6.2.3. GW/SW and Riparian Vegetation Modeling

Relationships between GW/SW and riparian vegetation will be developed using MODFLOW (Harbaugh 2005) and the associated RIP-ET (riparian-evapotranspiration MODFLOW package; Maddock et al. 2012).

Focus Area GW/SW sampling is designed to measure, and evaluate GW/SW hydroregime for all floodplain plant community types and successional stages, including plant establishment, plant recruitment, and mature forest vegetation. The sampling approach and design includes transects and arrays of groundwater wells and surface water stage stations. Complete groundwater sampling design details can be found in the Groundwater Study (see ISR Study 7.5, Section 4).

Riparian plant community field data were collected in 2013 and additional data will be collected in the next study year, in coordination with the Riparian Vegetation Study (see ISR Study 11.6).

4.6.2.4. Plant Transpiration

Data collection to characterize plant transpiration processes was initiated in 2013 using two methods: (1) continuous measurements of sap flow velocity made for woody species using the Grainer’s Thermal Dissipation Probe (TDP) method (Granier 1987); and (2) direct leaf-level stomatal conductance measurements collected for herbaceous and small shrub species using a solid-state leaf porometer (SC-1; Decagon Devices, Pullman, WA, USA). Detailed methods are provided below.

4.6.2.4.1. Sap Flow Measurement

Sap flow velocity of representative tree species, and size ranges, were measured for determining tree and plant community type transpiration rates for input into the MODFLOW groundwater model. In 2013, data collection was initiated to develop plant transpiration flux curves for five dominant floodplain woody plant species, *Populus balsamifera*, *Betula papyrifera*, *Picea glauca*, *Alnus incana* ssp. *tenuifolia*, and *Salix* species. Sap flow velocity was measured using the Grainer's Thermal Dissipation Probe (TDP) method with TDP-30 (30-millimeter-long (0.1 inch) needles) and TDP-80 (80-millimeter-long (0.3 inch)) sap flow sensors (Dynamax Inc., Houston, TX). Sap flow sensors were installed in trees and shrubs following methods provided in Dynamax (1997). Sensors were connected to a Campbell Scientific CR-1000 datalogger to continuously record data at established intervals (Campbell Scientific, Logan, UT, USA). Measurements of the difference in temperature (dT) between the heated upper probe (or needle) and the unheated lower probe (needle) were acquired in 60-second intervals and averaged every hour.

Depending on the DBH of the tree, between one and four sensors were installed into each tree so that an average flow rate could be calculated (Dynamax1997). Specifically, one or two sensors were installed on trees with DBH less than 24 centimeters (9 inches). Three sensors were installed on trees with DBH 25–35 centimeters (9.8–13.8 inches), and four sensors were installed on trees with DBH greater than 35 centimeters (13.8 inches). For trees with multiple sensors, sensor placement was oriented to balance any potential effect of direct sunlight on sap flow (e.g., east and west orientation for trees with two sensors; north, southwest, and southeast orientation for trees with three sensors; and northeast, southeast, southwest, and northwest orientation for trees with four sensors).

4.6.2.4.2. Direct Stomatal Conductance Measurements

To measure the water use of herbaceous and small woody species, direct leaf-level stomatal conductance measurements were made using a solid-state leaf porometer. Porometers measure the resistance of water as it moves from the plant tissue. Steady-state leaf porometer units (SC-1) were used to measure daily stomatal conductance for target species at FA-104 (Whiskers Slough) and FA-128 (Slough 8A) during sample periods in June (early-season), July (mid-season), and September (late-season). The September 2013 late-season sampling period was truncated due to wet weather conditions and only a partial dataset is available for this period. Sampling was conducted to document conductance by plant structural type (e.g., forb, sedge, shrub, tree seedling, tree) and by species.

In order to scale-up leaf measurements to vegetation cover type, or functional group scale, Leaf Area Index (LAI) was measured in four different canopy cover types within FA-104 (Whiskers Slough) and FA-128 (Slough 8A). LAI, a dimensionless quantity, is the leaf area (upper side only) per unit area of soil below it. It is expressed as square meter leaf area per square meter ground area. The active LAI is the index of the leaf area that actively contributes to the surface heat and vapor transfer and generally corresponds with the upper, sunlit portion of a dense canopy. LAI plots were set up to represent different vegetation cover types. LAI measurements were taken within three Focus Areas: FA-104 (Whiskers Slough), FA-115 (Slough 6A), and FA-128 (Slough 8A).

4.6.3. Riparian Plant-Frequency Response Curves

Floodplain vegetation−GW/SW regime functional groups are assemblages of plants that have established and developed under similar GW/SW hydrologic regimes. For the Riparian IFS, metrics will be developed for quantitatively describing the relationship between dominant floodplain plant communities and the GW/SW hydroregime. Probabilistic response curves will be developed for select plant species and sampled riparian plant community types using techniques described in Rains et al. (2004) and Henszey et al. (2004). The results of the individual plant species, and plant community type, response curve analyses will be used, along with plant species rooting depth measurement characterizations, to develop floodplain vegetation-GW/SW regime functional groups (Merritt et al. 2010; Rains et al. 2004).

Riparian plant-frequency response curves to water level gradients will be fit using non-linear models as described in Henszey et al. (2004). The non-linear models will be used with both individual species and plant community type data. As recommended by the FERC in the April 1 SPD, water-level summary statistics will be tested for best fit. Seasonal GW/SW hydroregime patterns will be measured using riparian groundwater wells and surface water level recorders as described in the Groundwater Study (see ISR Section 7.5). Riparian vegetation will be sampled at each groundwater wellhead using methods described in the Riparian Vegetation Study (see ISR Study 11.6). A number of surface water and groundwater pattern summary statistics will be evaluated to assess linkages of surface water and groundwater levels, and regimes, to plant frequency. Water level regime summary statistics will include, at a minimum (1) growing season 10 percent cumulative frequency water level, and (2) growing season 7-day moving average high water. Other, as yet to be determined, water level regime summary statistics will also be evaluated in the analysis. Non-linear models will be fit through the data to quantify the linkage between GW/SW hydroregime and plant frequency (Henszey et al. 2004). The analyses will result in multiple models each describing the frequency with which a given plant species or community type occurs primarily as a function of estimated groundwater and surface water statistics (e.g., mean depth during growing season, growing season 7-day moving average high water level). Therefore, an iterative statistical best-fit analysis will be conducted to create plant frequency response curve models. The Riparian IFS team conferred at two riparian technical meetings with members of the TWG in Q2 2013 concerning technical aspects of the riparian plant frequency response curve analysis. The Riparian IFS team will seek further input from interested TWG members concerning preliminary aspects of plant frequency response curve model analysis in 2014.

4.6.4. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season. Methods were refined from the RSP to the ISR as described in Section 4.6.2 above.

4.7. Floodplain Vegetation Study Synthesis, Focus Area to Riparian Process Domain Model Scaling and Project Operations Effects Modeling (hereafter, Riparian Vegetation Modeling Synthesis and Project Area Scaling)

The results of floodplain vegetation and soils mapping, forest succession models, seed dispersal study, seedling establishment studies, ice processes study, floodplain erosion and sediment transport study, and groundwater and surface water interaction study will be integrated into a conceptual ecological model of Susitna River floodplain vegetation and physical processes, including flow, sediment, and ice process regimes. The results of these studies will be used to develop a dynamic floodplain vegetation model for simulating floodplain vegetation response to Project operation modification of the natural flow, sediment, and ice process regimes (Franz and Bazzaz 1977; Benjankar et al. 2011; Springer et al. 1999).

Study objectives, methods, and expected results are summarized in Table 4.7-1.

Study objectives are to:

1. Develop conceptual ecological models of Susitna River floodplain vegetation establishment and recruitment based on synthesis of Riparian Vegetation Study and Riparian IFS results.
2. Scale-up results of Focus Area floodplain vegetation and physical process modeling results to riparian process domains.
3. Develop a dynamic, spatially-explicit floodplain vegetation model for simulating floodplain vegetation response to Project operation modification of the natural flow, sediment, and ice process regimes.
4. Develop spatially-explicit maps of modeled Project operations effects throughout the study area.
5. Provide guidance to environmental analysis of Project operations.

4.7.1. Methods

AEA is implementing the methods as described in the Study Plan with no variances.

The results of the Focus Area modeling will be scaled-up to the riparian process domains using spatially-explicit GIS-based models (Benjankar et al. 2011; Chacon-Moreno et al. 2007). The goal is to model both natural riparian flow-response functional groups and natural Susitna River physical process regimes to measure and map Project operational impacts to floodplain vegetation and riparian ecosystem processes throughout the study area. Recent developments in GIS, LiDAR-driven digital terrain models (DEMs), and geo-spatial analytical tools (ARCMAP, ESRI) have provided modelers the capacity to use the results of reach-scale analyses to scale-up to larger geospatially defined areas or domains (Benjankar et al. 2011; Chacon-Moreno et al. 2007). Modeling riparian vegetation response, over a 185-mile Susitna River valley, to alterations of natural flow regimes, is inherently a geospatial analytical problem. Current state-of-the-art and science practice will be utilized to integrate modeling of physical processes (HEC-

RAS, MODFLOW), and riparian vegetation-flow response functional groups with GIS geospatial analysis and display (ARCMAP, HEC-GEORAS).

The objectives of the Focus Area scaling model are as follows:

1. Scale-up Focus Area modeling results to riparian process domains.
2. Assess potential impacts of Project operational flows on downriver floodplain plant communities and ecosystem processes.
3. Provide guidance to environmental analysis of Project operations.

4.7.2. Variances from Study Plan

No variances from the methods described in this component of the Study Plan occurred in the 2013 study season.

5. RESULTS

5.1. Literature Review of Dam Effects on Downstream Vegetation

The Riparian IFS dam effects literature review on riparian vegetation will be combined with the Fluvial Geomorphology Modeling Study dam effects literature review. Considering that fluvial geomorphology and floodplain riparian ecology processes are interrelated, this coordinated effort will more fully serve the Project than would two uncoordinated reviews. The critical review will include an annotated, searchable bibliography with annotations of more than 100 references of riparian floodplain effects of hydroregulation. Information describing the "state-of-the-science" for floodplain effects of hydroregulation will be synthesized. This combined Fluvial Geomorphology Modeling and Riparian IFS critical literature review paper and annotated bibliography will be submitted in a Technical Memorandum in 2014.

5.2. Focus Area Selection−Riparian Process Domain Delineation

The results for the Middle River Segment delineation of riparian process domains paralleled the geomorphic reach classification conducted by the Fluvial Geomorphology Modeling team. The Middle River Segment delineation resulted in four representative Middle River Segment clusters or "riparian process domains." The Lower River Segment cluster analysis was less conclusive, and it was decided not to use the cluster analysis at this stage for the 2013 riparian vegetation sampling approach until further analysis could be conducted in the next study year. For the 2013 Lower River Segment vegetation sampling strategy, it was decided that the Riparian IFS would use the existing five Geomorphic Reach Classifications provided by the Fluvial Geomorphology Modeling team (Tetra Tech 2013).

Within the four Middle River Segment riparian process domains, eight Focus Areas were identified and selected for intensive surveys of physical process, vegetation sampling [see Riparian Botanical Survey (ISR Study 11.6, Section 4) for vegetation statistical sampling protocols], and riparian floodplain interaction modeling. The Focus Areas were those considered most representative of the riparian process domains in terms of vegetation structure and abundance, and channel/floodplain characteristics (channel planform, channel slope, channel confinement). Process domain variability was assessed in terms of vegetation composition, abundance, and structure within the selected Focus Areas relative to the associated riparian process domain (Table 5.2-1, Table 5.2-2, and Table 5.2-3). To capture variability in floodplain vegetation types, and geomorphic terrains within each riparian process domain not found within the Focus Areas, satellite study sites have been surveyed outside Focus Areas using the ITU riparian vegetation sampling protocols detailed in the Riparian Vegetation ISR (ISR Study 11.6, Section 4).

Of the potential riparian Focus Areas, two were located within the moderately confined domain, RPD-1, between the proposed dam site and Devils Canyon, and have narrow floodplains. Seven of the potential Focus Areas were located within the moderately confined domain, RPD-3, which extends downstream from Devils Canyon to the Transition Domain at FA-104 (Whiskers Slough) and have varying floodplain widths. One Focus Area is located in the short Transition domain, RPD-4, extending from the downstream end of the moderately confined process domain to Three Rivers Confluence. Distribution and abundance of vegetation types within each Focus Area were then compared to distribution and abundance of vegetation types across each riparian process domain (Table 5.2-1, Table 5.2-2, and Table 5.2-3). Overall, the analysis demonstrated that the vegetation types and abundance found within the eight Focus Areas provide a good representation of the types and relative abundance of vegetation found within the respective riparian process domains. As a result, these eight Focus Areas were given further consideration by the riparian study team.

The riparian technical team, which included representatives from USFWS and other agencies, met to discuss riparian vegetation classification and mapping and how the results of these studies would be used to inform selection of representative Focus Areas as well as the degree to which these FAs were representative of each riparian process vegetation types (February 21, 2013). During the meeting, each of eight Focus Areas were reviewed and five were selected for detailed study. Three not selected—FA-184 (Watana Dam), FA-171 (Stephan Lake Simple), and FA-144 (Side Channel 21)—were found to be lacking in one or more of the following characteristics: representative floodplain vegetation type, floodplain terrain complexity, or wetland complexity (see Table 5.2-4).

During the discussion, USFWS and NOAA representatives raised concerns regarding the adequacy of the riparian FAs in representing the herbaceous vegetation types along the Middle River. In response to these concerns, AEA conducted an additional analysis of the Middle River herbaceous plant community types. The results were used (1) to determine how well the selected FAs represented herbaceous vegetation within each RPD, and (2) to select additional areas outside the FAs ("satellite areas") in which to sample herbaceous vegetation, thus increasing sample plot number for herbaceous vegetation in RPDs where the selected FAs may under-represent complete RPD vegetation types. The conclusion of the analysis states:

"In areas of RPD-3 covered by ITU mapping, the low coverage of herbaceous vegetation types in several of the FAs suggests that FA-138 (Gold Creek) be included as a riparian focus area in RPD-3. Additionally, several satellite areas where herbaceous vegetation is abundant, including

between PRM 112–113, 125–127, and 132–133, will be incorporated into the 2013 sampling scheme.”

AEA prepared a technical brief summarizing the analysis, results, and conclusions (see Appendix A). Further analysis of 2013 field results will be conducted and additional herbaceous satellite areas will be selected for ITU sampling in the next study year. The final list of Focus Areas for Riparian IFS investigations is provided in Table 5.2-5 and depicted in Figure 5.2-1. The selected Focus Areas will be reviewed in the next study year using field data collected in 2013.

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the file titled ISR_8_6_RIFS_ProcessDomain.shp.

5.3. Seed Dispersal and Seedling Establishment

5.3.1. Seed Dispersal

Seed release study sites were established at four sites in the Lower and Middle River Segments (Figure 5.3-1): PRM 47 (Deshka Landing), PRM 88 (Parks Highway Bridge), PRM 102 (Talkeetna), and PRM 142 (Indian River) (Table 5.3-1, Figure 5.3-2, Figure 5.3-3, Figure 5.3-4, Figure 5.3-5). Catkins releasing seed from 6 female balsam poplar (*Populus balsamifera*) trees and 6 to 12 female willow (*Salix* spp.) shrubs were counted weekly at each seed release study site. Trees and shrubs were selected and counts were initiated on June 6, 7, and 8, 2013. Weekly counts continued throughout June and July. Weekly site visits were stopped when catkin counts remained stable for several weeks following peak catkin count. The final counts were completed on July 29 and 30, 2013. In total, eight counts were made at the PRM 47 and PRM 88 seed release study sites, and nine counts were made at PRM 142 and PRM 102 seed release study sites.

Continuous, 15-minute interval temperature records from January to July 2013 for the PRM 102 and PRM 142 sites were obtained from AEA weather stations. HOBO temperature sensors were installed to determine local temperatures on June 6 and June 8, 2013 at PRM 88 and PRM 47 sites, respectively. Because these HOBO sensors were installed midway through the year, June and July 2013 temperatures were used directly from the HOBO output and January to June 2013 temperatures at these sites were estimated using linear regression developed from correlation with the Talkeetna airport (National Climate Data Center, NOAA) mid-point temperatures ((Max-Min)/2). The prediction models were:

$$\text{PRM 47 temperature} = 1.2 + 0.94 * \text{Airport temperature}$$

$$\text{PRM 88 temperature} = 2.4 + 0.83 * \text{Airport temperature}$$

The temperatures used for each site are displayed in Figure 5.3-6. HOBO sensors were removed on October 6, 2013.

A preliminary degree-day model following the methods of Stella et al. (2006) was developed using 2013 seed release counts and the temperature records obtained from each site and the Talkeetna Airport. The duration of the peak seed release window, bounded by the 20th and 80th cumulative quantiles (DY_{20} to DY_{80}), was determined for poplar and willows at each site where sufficient data were collected in 2013 (Table 5.3-2). Plants were removed from analysis if they had fewer than 10 catkins or if the first count in June contained more than 20 percent of catkins releasing seed. Additionally, sites with fewer than three plants of a given species with estimable DY_{20} were not included in the summary table. Continuous, 15-minute interval Susitna River discharge data from the USGS discharge gage at Gold Creek was compared to peak seed release. Peak discharge appeared to occur from June 1 to 2, 2013. Depending on site, the peak period of seed release for poplar began 17 to 20 days following peak discharge (Figure 5.3-7 and Figure 5.3-8).

In addition to the degree-day threshold related to the initiation of seed release (DY_{20}), the base temperature representing the lower thermal limit to annual plant development was predicted using 2013 data. The accumulated degree-days for 26 integer base values from -5 to 20°C up to the site mean DY_{20} were estimated for each site (i.e., a 4 x 26 matrix of degree-days). The average degree-day trigger (across the four sites) for each potential base temperature was then used to "model" a DY_{20} for each site (i.e., a 4 x 26 matrix of predicted DY_{20}). These site-specific predictions were compared to the observed DY_{20} for each plant at that site, using the relative mean-squared error (RMSE). The base temperature that resulted in the lowest RMSE was 6°C (42.8°F). In other words, the estimated DY_{20} based on degree-days accumulated above 42.8°F was on average the closest to observed DY_{20} across plants. Thus, 6°C (42.8°F) is the estimated optimal base temperature. The average degree-days at or above the optimal base temperature accumulated at DY_{20} was used as the estimated "trigger" for seed release. For poplar, the estimated trigger (DY_{20}) is 260 degree-days. Using the same optimal base temperature, DY_{80} corresponds to 345 degree-days over 42.8°F. Willows were not used for modeling because there were not enough data for a single species and variance in seed release timing between willow species is high. The findings described are preliminary because they are based on only a single year of data. The seed release study will be repeated in a second study year, and models will be recalculated and revised as needed.

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the file titled ISR_8_6_IFS_Seed_Release.xls.

5.3.2. Seedling Establishment and Recruitment

5.3.2.1. First Year (0+) Balsam Poplar and Willow Seedling Establishment

During reconnaissance surveys of lateral margins in Focus Areas 104 (Whiskers Slough), 113 (Oxbow 1), 128 (Slough 8A), 138 (Gold Creek), and 144 (Side Channel 21), approximately 30 polygons with dense populations of first year seedlings were mapped. Following this reconnaissance mapping effort, transects were distributed across Focus Areas and across a range of geomorphic positions (e.g., main channel, side channel, slough, island head, island tail) as described in Table 5.3-3. A total of 35 first year (0+) balsam poplar and willow seedling establishment transects were documented in 17 of the mapped seedling polygons between July 30 and August 7, 2013 (Figure 5.3-9, Figure 5.3-10, Figure 5.3-11, Figure 5.3-12, Figure 5.3-13). Per the Study Plan, a second sampling effort was completed for the seedling establishment study between September 7 and September 11, 2013.

Transects were oriented perpendicular to the edge of water and extended upslope to where full canopy cover by trees or shrubs began. Transects ranged from 6.73 meters (22.1 ft) to 49.81 meters (163.4 ft) in length. Plots (0.25 meter x 0.25 meter; 0.8 ft x 0.8 ft) were placed at 1 meter (3.3 ft) intervals along each transect for a total of 824 plots distributed across the five Focus Areas. A total of 41,553 poplar and 7,643 willow seedlings were counted in the plots in the first survey effort (July 29–August 8). When seedlings in these plots were counted again for the second survey (September 7–11, 2013), only 11,498 poplar seedlings (28 percent) and 4,882 willow seedlings (64 percent) were counted. Survival rate between sites was highly variable with poplar seedling survival along individual transects ranging from 0.5 to 65 percent and willow seedling survival ranging from 0 to 90 percent. Seedling counts observed in each transect are grouped by Focus Area (Figure 5.3-14 and Figure 5.3-15) and by geomorphic position (Figure 5.3-16 and Figure 5.3-17) to illustrate survival patterns during Year 1 of the seedling establishment study.

Flows in June and July 2013 were moderate following the spring peak discharge shortly after break-up. The first sample event in late July and early August occurred during moderate flows. A peak flow event occurred between the first and second sampling periods with maximum discharge at Gold Creek of 49,100 cfs (Figure 5.3-18).

Fifteen wells were established at eight seedling establishment sites between August 5 and 9, 2013. Paired wells (one well at the approximate mid-point of the seedling plot transect and one well near the upper end of the transect) were installed at each well transect, except FA-138 (Gold Creek). Only a single well was installed at FA-138 (Gold Creek) because intensive groundwater monitoring was occurring in association with the Groundwater ISR Study 7.5 in the vicinity of this site. Water levels were measured in each well at least three times in August and September.

Seedling rooting depths were measured for ten randomly selected first year poplar seedlings rooted along Transect 1 in FA-104 (Whiskers Slough) on September 26 and 27. Seedlings were randomly selected from three distinct zones (0-6 meters, 6-12 meters, and 12-18 meters, with 0 m starting closest to flowing water) along the transect. Figure 5.3-19 presents rooting depths relative to shoot lengths observed for these 30 seedlings plotted by collection zone.

A total of 27 seedling composite samples were collected for isotope analysis along transects at FA-104 (Whiskers Slough), FA-113 (Slough 6A), and FA-128 (Slough 8A), to assess predominant water source. Seedling transects were labeled as the Focus Area number with the seedling transect number (STR) within the Focus Area. Representative seedling transects selected for isotope sample collection were FA-104 STR1, FA-113 STR2, and FA-128 STR1. Each seedling establishment transect sampled was divided into thirds and three composite samples were collected at each distance from surface water. Composite samples did not discriminate against species and were made up of hundreds of individual samples. Samples were predominantly made up of feltleaf willow (*S. alaxensis*) and poplar (*P. balsamifera*) seedlings. Attempts to sample groundwater were unsuccessful due to cold temperatures in September, freezing the water in the shallow wells. These samples will be processed by a stable isotope laboratory.

Figure 5.3-20, Figure 5.3-21, and Figure 5.3-22 provide the topographic survey along transects, depth to cobble, seedling density (in seedlings per square meter), and surface substrate estimates for two representative seedling establishment transects. Ocular estimates of surface substrate (sand/silt versus gravel/cobble) were conducted at each plot at each sampling period. In addition, sediment samples were collected at plots where seedlings survived to the September sample period. Sediment samples are being analyzed for sand, silt, and clay fractions with standard hydrometer methodology. These results will be available in 2014. Additional statistical analyses will be conducted following surveys in the next study year to assess relative importance of environmental factors on seedling survival.

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the file titled ISR_8_6_RIFS_StudyTransectsSE.shp.

5.3.2.2. Clonal Balsam Poplar and Willow Establishment and Recruitment

During surveys for the first year (0+) balsam poplar and willow seedling establishment study completed in Q2 and Q3 2013, reconnaissance surveys were conducted along channel lateral margins to assess patterns of clonal balsam poplar and willow establishment and recruitment. Clonal populations will be surveyed formally in the next study year with excavation of representative specimens and measurements of depth of burial, and height above floodplain surface.

5.3.2.3. White Spruce and Paper Birch Establishment and Recruitment

In 2013, to characterize white spruce establishment patterns, 12 8-meter-wide (26.25 feet wide) belt transects were surveyed covering approximately 3.5 hectares (8.7 acres) on seven mid-channel islands in the Middle River Segment. Two transects were surveyed at each of five islands and a single transect was surveyed on two islands (Table 5.3-4; Figure 5.3-23, Figure 5.3-24, Figure 5.3-25, Figure 5.3-26, and Figure 5.3-27). Surveys were designed to characterize spruce population density, size and distribution by age class (i.e., seedlings, trees, and snags). Seedling spruce were considered to be all individuals with heights less than 1.4 meters (4.5 ft) and spruce trees were considered to have heights greater than or equal to 1.4 meters (4.5 ft). This height was chosen as the cutoff because it is the height at which DBH can be measured, and a relationship may be developed between age and DBH. Spruce height estimates ranged from 0.1 to 25 meters (0.32 to 82 ft). Across all islands, a total of 426 spruce were recorded consisting of 226 seedling spruce and 200 tree and snag spruce. For the 200 spruce trees with heights greater than 1.4 meters (4.5 ft), DBH ranged from less than 1 cm to 41.5 cm (0.4 to 16.3 inches). Figure 5.3-28, Figure 5.3-29, and Figure 5.3-30 provide seedlings, tree, and snag spruce counts observed along each transect. Figure 5.3-31 and Figure 5.3-32 illustrate the distribution of seedling and spruce trees relative to position on the island.

On each island, between 5 and 12 spruce were randomly selected and sampled to determine age, height, DBH, depth of burial above the root collar and depth to cobble. The core samples are currently being processed using standard dendrochronology methods (Fritts 1976) described in Section 4.5.1 to determine age.

Sediment cores were assessed at 5 to 10 locations per island to determine the number and depth of layers with increased organic matter content in upper 30 cm (11.8 inches) of the soil profile

(Table 5.3-5; Figure 5.3-33). Alternating organic to mineral layers may be used to indicate flood-deposited sediment. The number of organic layers in the upper 30 cm (11.8 inches) ranged from one to eight with depth to cobble ranging from 28 cm (11.0 inches) to greater than 123 cm (48.4 inches) (Table 5.3-5). Figure 5.3-34 presents mean number of organic layers and mean depth to cobble observed at each island.

5.4. River Ice Effects on Floodplain Vegetation

Aerial mapping during ice break-up included observations of an area on islands located between PRM 134 and 135 in which ice-dam rafting of ice sheets had caused a high magnitude of disturbance of floodplain forest stands. The floodplain vegetation on an island in this area was subsequently sampled using standard dendrochronology plot and belt transect methods to document the extent and magnitude of floodplain vegetation disturbance (see Section 4.3.2.1 for methods).

A survey of tree ice-scars was conducted from PRM 102.2 to PRM 145.8 between September 15 and 29, 2013. River right and river left were surveyed from a jet boat using a Trimble GeoExplorer XT interfaced with a TruPulse 360 Laser to capture GPS point offsets. At 0.2-mile intervals, ice-scar survey points were established along river right and river left. At each ice-scar survey point, a GPS point and photographs were taken, the height of the floodplain surface above water level was measured, and the height of an ice-scar on one representative tree was measured, if any ice-scars were present. Occasionally, the view of an entire ice-scar was obstructed, or recent knock down of young vegetation was visible, but elevations could not be measured from the boat. In these cases ice damage was noted but not measured. Between each location, the number of ice-scarred trees that could be viewed from the river was counted. A total of 222 ice-scarred trees, 190 locations with no visible ice-scars, and 29 locations with signs of ice damage that were not measurable were surveyed. Thus, 441 locations were surveyed in total.

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the files titled ISR_8_6_IFS_IceScarData.xls and ISR_8_6_RIFS_IceScarSurvey.shp.

In addition to the systematic 0.2-mile survey locations along each bank, 48 ice-scarred trees were sampled for dendrochronologic analysis. Intensive ice-scar wedge sampling occurred at three Focus Areas: 13 samples were collected at FA-104 (Whiskers Slough), 20 from FA-115 (Slough 6A), and 15 from FA-128 (Slough 8A). Each sample consisted of a wedge that was removed from the tree with a 16-inch chainsaw (Figure 4.4-4). The wedge included the ice-scarred section and subsequent growth adjacent to the scar. At each sampled tree, GPS coordinates, photographs, floodplain height above water, ice-scar height above floodplain, and tree diameter at breast height were also measured. Dendrochronologic analyses will be performed on each wedge in Q4 2013 through early 2014 to date each ice-scarring event (Fritts 1976; Stoffel and Bollschweiler 2008).

The top of measured ice-scars ranged in height from 0.2 to 4.3 meters (0.66 to 14.1 ft) above the floodplain, and averaged 1.8 ± 0.7 meters (5.8 ± 2.4 ft) (Figure 5.4-1). Data from ice-scar wedge sampling in the three Focus Areas showed similar average ice-scar heights above the floodplain at three Focus Areas (Figure 5.4-2). Values for the height of the floodplain and ice-scar above water are not reported because measurements were taken on different days with varying river stage. Height above water level will be standardized when stage-discharge models are available.

Preliminary mapping of floodplains affected by ice processes was begun by importing point data into ArcGIS 10.1. Figure 5.4-3, Figure 5.4-4, Figure 5.4-5 show ice-scar mapping along representative reaches. Preliminary analysis is revealing areas where ice-scars were more frequent (e.g., Figure 5.4-3) and areas where ice-scars were less frequent (e.g., Figure 5.4-4). Figure 5.4-5 shows a representative reach along FA-104 (Whiskers Slough) where ice-scar sampling was completed along with ice-scar surveys.

5.5. Floodplain Stratigraphy and Floodplain Development

Sediment cores were collected during 2013 at 13 locations in the Middle River Segment, including 5 cores at FA-104 (Whiskers Slough) and 8 cores at FA-115 (Slough 6A) (Figure 5.5-1 and Figure 5.5-2). At both FA-104 (Whiskers Slough) and FA-115 (Slough 6A), sediment sample sites were located at ITU plot floodplain locations along transects perpendicular to the Susitna River. These samples will be analyzed for ^{210}Pb and ^{137}Cs isotopes.

Tree and shrub distribution and abundance were assessed by recording data at 80 ITU and mid-channel island plots in 2013. More than 450 cores and cookies representing approximately 250 trees and shrubs were collected in Q3 2012 and Q2 and Q3 2013. These cores are being analyzed in Q4 2013 and early 2014, so tree age data are not available for inclusion in this ISR.

Existing tree and shrub plot data are summarized by preliminary Viereck IV plant community type as mapped by Riparian Vegetation (Study 11.6) in 2012 (Table 5.5-1). Plot locations are shown in Figure 5.3-23, Figure 5.3-24, Figure 5.3-25, Figure 5.3-26, Figure 5.3-27, and Figure 5.5-1 and Figure 5.5-2).

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the files titled ISR_8_6_RIFS_StudySites.shp and ISR_8_6_RIFS_StudyTransects.shp.

5.6. Riparian GW/SW Hydroregime

5.6.1. Stable Isotope Analyses

Water isotope samples were collected during Q2 and Q3 2013 to characterize seasonal riparian plant species water acquisition sources. Sampling was focused on plant water samples (xylem tissue), soil water samples, and surface/groundwater samples, at FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Sampling occurred three times during the growing season (June, July, and September). All samples were collected along the GW/SW transects (Table 5.6-1; Figure 5.6-1, Figure 5.6-2, and Figure 5.6-3).

A total of 659 plant samples were collected in the summer of 2013 for isotopic analysis: 245 herbaceous samples, 206 shrub samples, and 208 tree samples. Sampling procedures focused on dominant floodplain plant species: *A. viridus ssp. crispa, A. incana ssp. tenuifolia, B. papyrifera,* *P. glauca, P. balsamifera, M. struthiopteris, V. edule, C. canadensis,* and a suite of unidentified *Salix* spp. (Figure 5.6-4; Table 5.6-1).

Soil cores were taken proximal to plant sampling locations to collect soil water samples at specific depths. A total of 545 soil samples were collected in 2013 (Table 5.6-2). Water samples were taken in conjunction with plant and soil samples. A total of 100 water samples were taken, with the majority being precipitation samples. Precipitation samples were collected throughout the growing season. Samples were collected along the GW/SW transects at every surface water source intersecting the transects (Table 5.6-3; Figure 5.6-1, Figure 5.6-2, and Figure 5.6-3). At least two 20-ml vials of water were taken at each source. Groundwater samples were collected in September following well installations.

All water samples will be extracted and analyzed by a stable isotope laboratory. Analysis and modeling will occur during the next study year.

5.6.2. Rooting Depth

Soil cores were taken in conjunction with soil isotope samples. During the 2013 growing season, 335 samples were collected, washed and sieved, and sorted. Currently, roots are frozen until they can be properly dried and weighed.

5.6.3. Plant Transpiration

During the summer months of 2013, TDP sensors were installed at 21 trees at FA-104 (Whiskers Slough) and 27 trees at FA-128 (Slough 8A) (Figure 5.6-1 and Figure 5.6-3). Sap flow sensors were first installed in mid-July at station ESGFA104-4 (Figure 5.6-1). Sap flow sensor installation was completed at FA-104 (Whiskers Slough) in late July 2013. Installation of sap flow sensors at FA-128 (Slough 8A) was completed in September 2013 (Figure 5.6-3). All sensors recorded data until October 10, 2013, except a few *P. glauca* trees at FA-104 (Whiskers Slough). At these select *P. glauca* trees, sampling continued through the end of October to ascertain the seasonal extent of transpiration.

A total of 98 sap flow sensors were installed into 38 trees/shrubs during Q2 and Q3 2013. These trees/shrubs included seven *A. incana* ssp. *tenuifolia*, eight *B. papyrifera*, ten *P. glauca*, seven *P. balsamifera* trees, and six unidentified *Salix* sp. (Table 5.6-4). All sap flow sensors were installed at stations across the GW/SW transects, with four stations at FA-104 (Whiskers Slough) and FA-128 (Slough 8A) (Figure 5.6-1 and Figure 5.6-3). Having multiple sites per transect allowed for comparison of sap velocity between trees close to the Susitna River (ESGFA104-8) and trees located far up into the floodplain (ESGFA104-4; Figure 5.6-5).

Individual trees and shrubs across the range of stem diameters present across the Middle River floodplain forests were selected for sap flow measurements. Average DBH for sample trees are as follows: *A. tenuifolia* (10.57 cm±4.95), *B. papyrifera* (27.48 cm±6.98), *P. glauca* (33.34 cm±8.29), *P. balsamifera* (92.59 cm±36.99), and unidentified *Salix* species (10.24 cm±5.85). Difference in temperature measured (dTM) and sap velocity are being recorded to dataloggers. Sap velocity reduced dramatically after leaves dropped in the fall, effectively ending seasonal transpiration (Figure 5.6-6). Preliminary analysis results comparing randomly selected sap velocity data with Vapor Pressure Deficit (VPD) are presented in Figure 5.6-5. VPD is the difference of water vapor concentration inside and outside the leaf; it is a good indicator for potential transpiration. During higher VPD days, there is a large gradient from outside the leaf to inside the leaf initiating water vapor movement, meaning higher potential for transpiration. When day-to-day VPD, measured at FA-104 (Whiskers Slough) (Figure 5.6-5 (c)) is compared to sap flow velocity measured at FA-104 (Whiskers Slough) (Figure 5.6-5 (a) and (b)), the trends are very similar.

Stomatal conductance was measured to quantify transpiration of herbaceous species and small woody shrubs. Stomatal conductance measurements were collected at FA-104 (Whiskers Slough), FA-115 (Slough 6A), and FA-128 (Slough 8A) during Q2 and Q3 2013. The bulk of conductance measurements were made in June and July at FA-104 (Whiskers Slough) and FA-128 (Slough 8A) (Table 5.6-5 and Table 5.6-6). Additional measurements were made at FA-115 (Slough 6A) in July to verify if sampling methods would work in *Carex* spp. meadows. Throughout the summer, a total of 3,602 individual stomatal conductance measurements were made. This included measurements from 1,747 herbaceous plants (11 species), 1,771 shrubs (11 species), and 79 trees (3 species). The average daily conductance of the entire dataset is 262.9 mmol $m^{-2}s^{-1}$±143.7. Both the maximum and minimum stomatal conductance were recorded on June 11, 2013. The minimum conductance was 12.9 mmol $m^{-2}s^{-1}$, recorded from *Trientalis europaea* at 9:46 am. The maximum stomatal conductance measured was 965.8 mmol $m^{-2}s^{-1}$, recorded from *Salix alaxensis* at 1:26 pm. Distribution of stomatal conductance values from several species is provided in box plots (Figure 5.6-7 and Figure 5.6-8). Late season (mid-September 2013) conductance measurements were cut short due to wet weather accompanied by leaf senescence.

Leaf Area Index (LAI) measurements were made along the GW/SW transects at FA-104 (Whiskers Slough), FA-115 (Slough 6A), and FA-128 (Slough 8A). LAI transects were chosen in areas that represented distinct plant community canopy cover types. Poplar sites were exclusively dominated by *P. balsamifera*, spruce/ birch sites were dominated by a *B. papyrifera* and *P. glauca* overstory canopy, and alder/willow sites were dominated *Alnus* and *Salix* species. (Figure 5.6-1, Figure 5.6-2, Figure 5.6-3, and Figure 5.6-9). Throughout the summer a total of 597 sample points were recorded using a hand-held ceptometer.

Similar to seasonal isotope sampling and conductance measurements, LAI was measured three times throughout the growing season in 2013. Measured LAI was greatest in July when all leaves had fully emerged. The third sampling period took place in mid-September (September 13 and 22). The majority of leaves had fallen by this sampling effort and LAI results are shown as lower than in the first two sample periods.

Volumetric soil water content sensors were installed adjacent at FA-104 (Whiskers Slough) and FA-128 (Slough 8A). The sensors were installed on August 16 and September 17, 2013 at FA-104 (Whiskers Slough) and FA-128 (Slough 8A), respectively. Sensors were installed at depths of 5, 10, 20, 50, 110, and 200 cm and at 5, 10, 25, 44, 65, and 85 cm at FA-104 (Whiskers Slough) and FA-128 (Slough 8A), respectively. The depth to cobble layer was much shallower at FA-128 (Slough 8A) than at FA-104 (Slough 6A) and thus sensors were only placed to a depth of 85 cm. During the month of September, soil moisture at shallow depths responded rapidly to precipitation (Figure 5.6-10). Soil moisture at intermediate depths (20 and 50 cm) showed delayed responses of a couple of days, while deeper depths (110 cm and 200 cm) remained consistently saturated during the month of September (Figure 5.6-10).

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr. This data is provided in the files titled ISR_8_6_RIFS_StudySites.shp and ISR_8_6_RIFS_StudyTransects.shp.

5.7. Floodplain Vegetation Modeling Synthesis and Project Scaling

The floodplain vegetation modeling approach was further developed as planned throughout 2013 based upon riparian IFS field results and refinement of Ice Processes (Study 7.6), FA-IFS (Study 8.5) and Fluvial Geomorphic Modeling (Study 6.6) efforts. Further, TWG input concerning development of floodplain vegetation modeling and project scaling will be sought in 2014.

6. DISCUSSION

6.1. Literature Review of Dam Effects on Downstream Vegetation

While it was proposed in the Study Plan that the literature review would be a part of the ISR submittal, it has become clear that the literature review and annotated bibliography will be more suitable as a stand-alone technical memorandum. Producing the literature review in coordination with the Fluvial Geomorphology Modeling Study (Study 6.6) will provide a more integrated and user-friendly document than if two separate documents were developed. While this is a change in format from what was proposed in the Study Plan, there are no impacts on meeting the objectives of this study and thus it was not considered a variance. This review is scheduled to be submitted in 2014. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.2. Focus Area Selection−Riparian Process Domain Delineation

Focus Areas for the Riparian IFS studies (primary riparian study sites) were selected in 2013 per methods described in Section 4. Riparian study site selection was further discussed in the Focus Area Selection Technical Memorandum (R2 Resource Consultants 2013) and details presented at Riparian Technical Meetings held in 2013 (April and June 2013). As stated in the Study Plan, riparian process domain definition will be further refined as needed based upon 2013 field surveys data. The floodplain Focus Area Selection – Riparian Process Domain Delineation will integrate results from interrelated studies in the next study year. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.3. Seed Dispersal and Seedling Establishment

During Q2-Q3 2013, the seed dispersal and seedling establishment study met objectives outlined in the Study Plan. The seed release study completed weekly counts of open catkins releasing seed for *Populus balsamifera* trees and *Salix* spp. shrubs at four locations in the Lower and Middle River Segments. Local temperature data were collected at each study site and from the Talkeetna Airport. Initial models were developed to correlate temperature at each of the seed dispersal study site with the Talkeetna Airport where long-term climate records are available. Additional temperature data will be collected from local sensors in the next study year to increase climate model accuracy. Susitna River discharge was obtained from the USGS Gold Creek and Sunshine discharge stations with historic records dating to the 1950s. The 2013 data provides preliminary degree-day modeling for *Populus balsamifera, Salix alaxensis, Salix barclayi,* and *Salix sitchensis.* Models will be rerun and refined after a second year of data collection. A recruitment box model for *P. balsamifera* and *Salix* spp. will be developed to provide insight for decisions on operational flows that facilitate seedling establishment of these Salicaceae riparian species.

For the seedling establishment study, transects were set up, marked, and seedling populations were counted in each plot twice during the 2013 growing season to capture the long-term bimodal summer discharge trend. A peak flow event occurred between the two sampling efforts. As expected, in large part due to the late August peak flow, mortality occurred between the August and September study efforts, and many of the seedlings were lost between the first and second sampling efforts. Because only poplar and willow first-year (0+) seedlings were documented along these seedling establishment transects, additional methods have been developed to describe seedling recruitment patterns for other dominant woody species, white spruce and paper birch and clonal recruitment patterns for poplar and willow. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.4. River Ice Effects on Floodplain Vegetation

During Q3 2013, river ice and floodplain vegetation modeling study objectives were met through tree ice-scar surveys and tree ice-scar dendrochronologic sampling. Ice-scar surveys were completed along 33.6 miles of the Susitna River Middle River Segment, and samples were collected for ice process dating in three Focus Areas. Mapping of survey data was initiated to inform in development of the floodplain vegetation study for the next study year. During Q3 2013, interviews were tentatively set up with local residents to discuss historic ice dams; however, weather conditions and unforeseen fieldwork needs prevented these meetings from taking place. They will be rescheduled during the next study year. Access to certain reaches along the river was limited due to low discharge during surveying at the end of September 2013. As a result, ice-scar information for a few sections of the main channel (near PRM 127) and along most side channels was not obtained in 2013. Additional surveys will be completed in the next study year to increase coverage of the ice-scar dataset in the Middle River Segment. Select reaches in the Lower River Segment will be surveyed in the next study year. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.5. Floodplain Stratigraphy and Floodplain Development

Project objectives are being met for the Floodplain Stratigraphy and Floodplain Development study effort. Thirteen soil core samples were collected for isotope analysis. Tree and shrub distribution and abundance were quantified at 80 Riparian Vegetation (Study 11.6) ITU and Riparian IFS mid-channel island plots. Tree cores were collected and are being analyzed to determine age distribution at select locations in the floodplain. These 2013 results are being analyzed in combination with the Riparian Vegetation (Study 11.6) to characterize plant communities along the floodplain and refine vegetation maps. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.6. Riparian GW/SW Hydroregime

During 2013, objectives set in the Study Plan were met relative to collection of representative water samples for plant water isotope sources determination. During this time period, over 1,200 total plant xylem samples, soil water, slough, main channel, rain, and groundwater samples were collected. Through cryogenic distillation processes, water will be removed from samples and all water isotope samples will be analyzed. Once results are received from the stable isotope lab, samples will be compared through a mixing model (Dawson et al. 2002). Upon review of isotope analyses results, adjustments to sample size for the next study year will be confirmed.

The study is progressing toward meeting objectives set in the Study Plan and technical team meetings to collect the necessary data needed to build transpiration curves for MODFLOW modeling. During 2013, all instrumentation infrastructure was successfully installed by the end of Q3, allowing for full GW/SW interactions to be monitored during the next study year. All sap flow arrays were installed and tested by the end of September as well as a total of eight stations across the GW/SW transect, with four stations at FA-104 (Whiskers Slough) and four at FA-128 (Slough 8A). Figure 5.6-5 shows that data collected to date shows typical responses for transpiration relative to meteorological drivers. All instrumentation infrastructure is in place for a complete capture of sap flow during the next growing season.

Over 3,000 stomatal conductance measurements were made during Q2-Q3 of 2013. During the 2013 growing season, Riparian-IFS crews completed two successful sampling periods at FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Late-season measurements were cut short due to wet weather, which led to early senescence of leaves. Initial conductance modeling began in Q4 of 2013, but these results are not yet available for this ISR.

In addition to transpiration measurements, LAI was measured in a suite of community types, soil moisture probes were installed at FA-104 (Whiskers Slough) and FA-128 (Slough 8A), and weather stations were installed at FA-104 (Whiskers Slough), FA-115 (Slough 6A), and FA-128 (Slough 8A). LAI measurements will be incorporated into transpiration models. Three seasonal measurements of LAI will be conducted at FA 115 (Slough 6A) in the next study year. Data from meteorological weather stations covering three FAs across the Middle River will provide data necessary for evapotranspiration (ET) models. This study is meeting study objectives set forth in the FERC-approved Study Plan.

6.7. Floodplain Vegetation Modeling Synthesis and Project Scaling

A synthesis of all Riparian IFS study results, and results of supporting modeling studies, will inform development of a conceptual ecological model of Susitna River floodplain vegetation and physical processes. Riparian IFS and supporting studies include (1) floodplain vegetation and soils mapping, forest succession models (Riparian Vegetation Study 11.6); (2) seed dispersal study, seedling establishment studies, Ice Processes Study (Study 7.6); (3) floodplain erosion and sediment transport study (Geomorphology Study 6.5); and (4) groundwater and surface water interaction study (Groundwater Study 7.5). The approach to scaling of riparian Focus Area results to riparian process domain will be developed and reported in the USR. The conceptual ecological model, and scaling approach, will form the framework for development of the floodplain vegetation model for simulating floodplain vegetation response to Project operational modification of the natural flow, sediment, and ice processes regimes to be conducted in the next study year. This study is meeting study objectives set forth in the FERC-approved Study Plan.

7. COMPLETING THE STUDY

[Section 7 appears in the Part C section of this ISR.]

8. LITERATURE CITED

Aalto, R., L. Maurice-Bourgoin, T. Dunne, D.R. Montgomery, C.A. Nittrouer, and J. Guyot. 2003. Episodic sediment accumulation on Amazonian flood plains influenced by El Nino/Southern Oscillation. *Nature* 425: 493-497.

Aalto, R., J.W. Lauer, and W.E. Dietrich. 2008. Spatial and temporal dynamics of sediment accumulation and exchange along Strickland River floodplains (Papua New Guinea) over decadal-to-centennial timescales. *Journal of Geophysical Research* 113: 1-22.

AEA (Alaska Energy Authority). 2012. Revised Study Plan: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2012. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/study-plan.

Amlin, N.M. and S.B. Rood. 2002. Comparative tolerances of riparian willows and cottonwoods to water-table decline. *Wetlands* 22: 338-346.

Baird, K.J. and T. Maddock. 2005. Simulating riparian evapotranspiration: a new methodology and application for groundwater models. *Journal of Hydrology* 312: 176-190.

Benjankar, R., G. Egger, K. Jorde, P. Goodwin and N.F. Glenn. 2011. Dynamic floodplain vegetation model development for the Kootenai River, USA. *Journal of Environmental Management* 92: 3058-3070.

Braatne, J.H., S.B. Rood and P.E. Heilman. 1996. Life history, ecology, conservation of riparian cottonwoods in North America. In: *Biology of Populus and its Implications for Management and Conservation* (Eds. R.F. Stettler, H.D. Bradshaw, P.E. Heilman and T.M. Hinckley), pp. 57-86. NRC Research Press, Ottawa.

Chacon-Moreno, E., J.K. Smith, A.K. Skidmore, H.H.T. Prins and A.G. Toxopeus. 2007. Modeling spatial patterns of plant distribution as a consequence of hydrological dynamic processes in a Venezuelan flooding savanna. *Ecottopicos* 20: 55-73.

Cooper, D.J., D.R. D'Amico, and M.L. Scott. 2003. Physiological and morphological response patterns of Populus deltoides to alluvial groundwater pumping. *Environmental Management* 31(2): 215-226.

Cooper, D.J., D.M. Merritt, D.C. Anderson and R.A. Chimner. 1999. Factors controlling the establishment of Fremont cottonwood seedlings on the upper Green River, USA. *Regulated Rivers: Research & Management* 15: 419-440.

Dawson, T.E. and J.R. Ehleringer. 1991. Streamside trees that do not use streamside water. *Nature* 350: 335-337.

Dawson, T.E., J.R. Ehleringer, A.E. Hall, and G.D. Farquhar. 1993. Water sources of plants as determined from xylem-water isotopic composition: perspectives on plant competition, distribution, and water relations. In: *Stable isotopes and plant carbon-water relations*. (pp. 465-496). Academic Press Inc.

Dawson, T.E., S. Mambelli, A.H. Plamboeck, P.H. Templer, and K.P. Tu. 2002. Stable isotopes in plant ecology. *Annual Review of Ecology and Systematics*, 507-559.

Dynamax. 1997. *Thermal Dissipation Probe User Manual*. Houston, TX. 12 pp.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. USDI, Bureau of Land Management, 492 pp.

Engstrom, J., R. Jansson, C. Nilsson and C. Weber. 2011. Effects of river ice on riparian vegetation. *Freshwater biology* 56: 1095-1105.

Flanagan, L.B. and J.R. Ehleringer. 1991. Stable isotope composition of stem and leaf water: applications to the study of plant water use. *Functional Ecology* 5: 270-277.

Franz, E.H. and F.A. Bazzaz. 1977. Simulation of vegetation response to modified hydrologic regimes: a probabilistic model based on niche differentiation in a floodplain forest. *Ecology* 58: 176-183.

Fritts, H.C. 1976. *Tree Rings and Climate*. New York: Academic Press.

Gower, J.C. 1971. A general coefficient of similarity and some of its properties. *Biometrics* 27:857-871.

Granier, A. 1987. Evaluation of transpiration in a Douglas fir stand by means of sap flow measurements. *Tree Physiology* 3: 309-320.

Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16.

Harza-Ebasco 1985. Riparian vegetation success report. Draft June 1985. Prepared by University of Alaska for Harza-Ebasco and Alaska Power Authority. 170 pp.

Helm, D.J., and W.B. Collins. 1997. Vegetation succession and disturbance on a boreal forest floodplain, Susitna River, Alaska. *Canadian Field-Naturalist* 111: 553–566.

Henszey, R.J., K. Pfeiffer, and J.R. Keough. 2004. Linking surface and ground-water levels to riparian grassland species along the Platte River in Central Nebraska, USA. *Wetlands* 24: 665-687.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54:187–211.

Ingraham, N. and R. Criss. 1993. Effects on surface area and volume on the rate of isotopic exchange between water and water vapor. *Journal of Geophysical Research* 98(D11): doi: 10.1029/93JD01735. issn: 0148-0227.

Jackson, R. B. 1999. The importance of root distributions for hydrology, biogeochemistry, and ecosystem functioning. In: *Integrating Hydrology, Ecosystem Dynamics, and Biogeochemistry in Complex Landscapes* (Eds. J. Tenhunen, P. Kabat, Dahlem Conference), pp. 219-240. John Wiley and Sons, Chichester.

Karrenberg, S., P.J. Edwards and J. Kollmann. 2002. The life history of Salicaceae living in the active zone of floodplains. *Freshwater Biology* 47: 733-748.

Kulmatiski, A., K.H. Beard, and J.M. Stark. 2006. Exotic plant communities shift water-use timing in a shrub-steppe ecosystem. *Plant and Soil* 288(1-2): 271-284.

Lajtha, K. and J. Marshall. 1994. Sources of variation in the stable isotopic composition of plants. In: *Stable isotopes in ecology and environmental science*. (Eds. K Lajtha and R H Michener) p. 316. Wiley-Blackwell.

Legendre, P. and L. Legendre. 2012. *Numerical Ecology*. Third English Edition. Elsevier, Amsterdam, The Netherlands.

LeRoux, X., T. Bariac, and A. Mariotti. 1995. Spatial partitioning of the soil water resource between grass and shrub components in a West African humid savanna. *Oecologia* 104(2): 147-155.

Ludwig, F., T.E. Dawson, H.H.T. Prins, F. Berendse and H. Kroon. 2004. Belowground competition between trees and grasses may overwhelm the facilitative effects of hydraulic lift. *Ecology letters* 7(8): 623-631.

Maddock, T. III, K.J. Baird, R.T. Hanson, W. Schmid, and H. Ajami. 2012. RIP-ET: A riparian evapotranspiration package for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A39, 76 p.

Mahoney, J.M. and S.B. Rood. 1998. Stream flow requirements for cottonwood seedling recruitment−an integrative model. *Wetlands* 18: 634-645.

Merritt, D.M., M.L. Scott, N.L. Poff, G.T. Auble and D.A. Lytle. 2010. Theory, methods and tools for determining environmental flows for riparian vegetation: riparian vegetation flow response guilds. *Freshwater Biology* 55: 206-225.

Montgomery, D. 1999. Process domains and the river continuum. *Journal of the American Water Resources Association* 35(2): 397-410.

Mouw, J.B., J.A. Stanford, and P.B. Alaback. 2009. Influences of flooding and hyporheic exchange on floodplain plant richness and productivity. *River Research and Applications* 25: 929-945.

Mouw, J.E.B., J.L. Chaffin, D.C. Whited, F.R. Hauer, P.L. Matson and J.A. Stanford. 2012. Recruitment and successional dynamics diversify the shifting habitat mosaic of an Alaskan floodplain. *River Research and Applications*. Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10: 10.1002/rra.2569.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. Wiley, New York.

Naiman, R.J., K.L. Fetherston, S.J. McKay, and J. Chen. 1998. Riparian forests. Chapter 12 In Naiman, R.J. and R.E. Bilby, *River Ecology and Management, Lessons from the Coastal Pacific Northwest*. Springer, New York.

Prowse, T.D. and S. Beltaos. 2002. Climatic control of river-ice hydrology: a review. *Hydrological Processes* 16: 805-822.

Prowse, T.D. and J.M. Culp. 2003. Ice break-up: a neglected factor in river ecology. Canadian Journal of Civil Engineering 30: 128-144.

R Development Core Team. 2011. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

R2 Resource Consultants. 2013. Technical memorandum: Adjustments to Middle River Focus Areas. Prepared for Alaska Energy Authority. May 2013.

R2 (R2 Resource Consultants, Inc.) 2013b. Technical Memorandum, Selection of Focus Areas and Study Sites in the Middle and Lower Susitna River for Instream Flow and Joint Resource Studies – 2013 and 2014. Susitna-Watana Hydroelectric Project, FERC No. P-14241. Prepared for Alaska Energy Authority, Anchorage, Alaska. 88 pp. March 2013. http://www.susitna-watanahydro.org/wp-content/uploads/2013/03/Attachment-C.pdf.

R2 Resource Consultants, Inc., GW Scientific and ABR, Inc. 2013. Technical Memorandum: Riparian IFS, Groundwater and Riparian Vegetation Studies FERC Determination Response. Prepared for AEA June 2013. 12 pp.

Rains, M.C., J.F. Mount, and E.W. Larsen. 2004. Simulated changes in shallow groundwater and vegetation distributions under different reservoir operations scenarios. *Ecological Applications* 14: 192-207.

Richards, K., J. Brasington and F. Hughs. 2002. Geomorphic dynamics of floodplains ecological implications and a potential modeling strategy. *Freshwater Biology* 47: 559-579.

Rood, S.B., S.G. Bigelow and A.A. Hall. 2011. Root architecture of riparian trees: river cut banks provide natural hydraulic excavation, revealing that cottonwoods are facultative phreatophytes. *Trees* 25: 907-917.

Rood, S.B., J.H. Braatne and F.M.R. Hughs. 2003. Ecophysiology of riparian cottonwoods:stream flow dependency, water relations and restoration. *Tree Physiology* 23: 1113-1124.

Rood, S.B., L.A. Goater, J.M. Mahoney, C.M. Pearce and D.G. Smith. 2007. Floods, fire, and ice: disturbance ecology of riparian cottonwoods. *Canadian Journal of Botany* 85: 1019-1032.

Rood, S.B., G.M. Samuelson, J.H. Braatne, C.R. Gourley, F.M.R. Hughes, and J.M. Mahoney. 2005. Managing river flows to restore floodplain forests. *Frontiers in Ecology and the Environment* 3(4): 193-201.

Scholl, M. 2006. Precipitation isotope collector designs. U.S. Geological Survey, 02 Feb 2006. Web. March 5, 2013.

Soil Survey Staff. 2009. Soil survey field and laboratory methods manual. Soil Survey. Investigations Report No. 51, Version 1.0. R. Burt (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Springer, A.E., J.M. Wright, P.B. Shafroth, J.C. Stromberg and D.T. Patten. 1999. Coupling groundwater and riparian vegetation models to assess effects of reservoir releases. *Water Resources Research* 35: 3621-3630.

Stella, J.C., J.J. Battles, B.K. Orr, and J.R. McBride. 2006. Synchrony of seed dispersal, hydrology and local climate in a semi-arid river reach in California. *Ecosystems* 9: 1200-1214.

Stoffel, M. and M. Bollschweiler. 2008. Tree-ring analysis in natural hazards research – an overview. *Nat. Hazards Earth Syst. Sci.*, 8, 187–202.

Tetra Tech. 2013. Initial Geomorphic Reach Delineation and Characterization, Middle and Lower Susitna River Segments. Draft 2012 Study Technical Memorandum prepared for Alaska Energy Authority, February 12, 2013. 34 pp.

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick, K.J. 1992. *The Alaska vegetation Classification*. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 278 p

Walker, L.R., and F.S. Chapin III. 1986. Physiological controls over seedling growth in primary succession on an Alaskan floodplain. *Ecology* 67: 1508-1523.

Walker, L.R., J.C. Zasada, and F.S. Chapin, III. 1986. The role of life history processes in primary succession on an Alaskan floodplain. *Ecology* 67: 1243-1253.

Wilson, K. B., P.J. Hanson, P.J. Mulholland, D.D. Baldocchi and S.D. Wullschleger. 2001. A comparison of methods for determining forest evapotranspiration and its components: sap-flow, soil water budget, eddy covariance and catchment water balance. *Agricultural and Forest Meteorology* 106(2): 153-168.

Winter, T.C. 2001. The concept of hydrologic landscapes. *Journal of the American Water Resources Association* 37: 335-349.

9. TABLES

Table 4.1-1. Floodplain Vegetation and Physical Process Regimes Critical Review, Synthesis and Lessons Learned.

STUDY OBJECTIVES
1. Conduct a critical review of previous Susitna River 1980s floodplain vegetation studies. 2. Conduct a critical review, and synthesis of relevant findings, of circumpolar, temperate and boreal regions, scientific research concerning dam effects on down river floodplain plant communities. 3. Conduct critical review, and synthesis of relevant current scientific research, concerning temperate and boreal floodplain forest succession and dynamics under natural flow regimes.
METHODS
1. Search libraries and internet for relevant scientific literature. 2. Develop annotated, searchable bibliography. 3. Develop critical review paper with thematic format: a. first, identify critical floodplain ecological processes effected by dams, b. second, compare Project dam operations under current design and compare with scientific literature reported effects, c. third, identify potential alternative operation scenarios to limit effects.
EXPECTED RESULTS
1. State of the science review of scientific findings concerning dam effects on down river floodplain plant communities. 2. Summary of expected effects of Project operations on Susitna River floodplain plant communities and ecosystems. 3. Set of guidelines for limiting Project operations effects based on current science.

Table 4.2-1. Focus Area Selection−Riparian Process Domain Delineation.

STUDY OBJECTIVES

1. Develop a riparian process domain stratification of the study area.
2. Select Focus Areas representative of each riparian process domain for physical process and vegetation survey sampling and modeling.

METHODS

1. Riparian process domain delineation, and riparian Focus Area selection is an iterative process.
2. In Q1 21013 the results of the 2012 Fluvial Geomorphology Modeling Study and channel classification (Section 6.6), ice processes study (Section 7.6), riparian botanical survey (Section 11.6) were used to classify channel, floodplain and floodplain vegetation types.
3. Constrained cluster analysis will be performed on channel, floodplain and vegetation types.
4. Process domain type variability was statistically described and analyses were performed to determine the number of Focus Areas necessary to capture process domain variability in the stratified sampling approach.
5. Candidate Focus Areas previously identified through the expert-opinion process for both Fish and Aquatics IFS (FA-IFS) and Riparian IFS were reviewed.
6. Results of the cluster analysis, power analysis and expert-opinion process will be presented to the TWG for final selection of Focus Areas.
7. Ice process mapping results, completed in Q4 2013, will be used in a second round of riparian process domain analysis and Focus Area selection.
8. Results of second iterative analysis will be used to assess whether additional Focus Areas are needed to capture ice process effects for subsequent field sampling.

EXPECTED RESULTS

1. Hierarchical stratification of Susitna River Study Area into riparian process domains.
2. Statistically robust selection of representative riparian process domain Focus Areas.
3. Study Area floodplain vegetation and physical process sampling and characterization necessary to support model scaling of Focus Area study results to riparian process domain.

Table 4.3-1. Synchrony of Seed Dispersal, Hydrology, and Local Susitna River Valley Climate.

STUDY OBJECTIVES

1. Measure balsam poplar and select willow species seed dispersal timing.
2. Model local Susitna River valley climate, and associated seasonal peak flows, relative to balsam poplar and willow seed dispersal.
3. Develop a recruitment box model of seed dispersal timing, river flow regime, and balsam poplar and willow seed dispersal and establishment.

METHODS

1. Conduct a two-year field survey of seed release of balsam poplar and select willow species.
2. Develop a ‘degree-day’ climate model for the onset of seed release relative to local temperature conditions using methods developed by Stella et al. (2006).
3. Analyze the historic climate and Susitna River flow regime relationship.

EXPECTED RESULTS

1. Degree-day model of peak seed release window using seed release observations and continuous temperature records from each floodplain sample site.
2. Recruitment box model of balsam poplar and select willow species.
3. Model of peak runoff / seed release temporal synchrony for operational flow guidelines.
4. Model of critical summer flow regime necessary to support seedling establishment.

Table 4.3-2. Seedling Establishment and Recruitment Study.

STUDY OBJECTIVES
1. Map and characterize seedling establishment and recruitment of dominant woody riparian species including balsam poplar, white spruce, paper birch, thinleaf and mountain alder, feltleaf willow, and Barclay's willow throughout the Focus Area lateral channel margins, and floodplains. 1. .Use a stratified random sampling approach, with variable plot sizes (Mueller-Dombois and Ellenburg 1974) to sample mapped seedling polygons. 2. Identify seedlings to species, and measure seedling heights and density. 3. Describe and measure seedling site soil characteristics 4. Measure and model seedling site GW/SW hydroregimes. 5. Measure seedling xylem water source through isotopic analysis 6. Investigate ice process seedling site interactions through empirical observations and ice process modeling. 7. Develop a probabilistic model of seedling hydrologic, sediment, and ice regime processes.
METHODS
1. Survey sampling approach is as follows. 2. First, helicopter and on-the-ground reconnaissance surveys of each reach were conducted to locate and map observable seedling areas. 3. Second, four to eight transects were placed systematically throughout the reach normal to main channel, extending across the adjacent floodplain intersecting observed seedling sites. Each transect was traversed and all remotely observed, and newly identified on-the-ground seedling locations were mapped with GPS. 4. Third, seedling site polygon boundaries were mapped with GPS. 5. Fourth, seedling patches were sampled using a stratified random approach to locate sample plots. Seedling species were identified, or collected for herbarium identification, and abundance (density) and height measured using variable plot size and shapes (Elzinga et al. 1998; Mueller-Dombois and Ellenberg 1974). 6. Fifth, at each plot two to three seedlings of each species were excavated and rooting depth measured. Excavated woody seedlings were aged at the root collar in the laboratory and annual rings counted to provide seedling age. Substrate texture and depth to cobbles were described and measured in soil pits excavated to 50 cm in depth or to gravel/cobble refusal layer. 7. Sixth, a subsample of Focus Area site seedlings was collected for xylem isotopic analyses to identify source of water (see Section 8.6.3.6). 8. Seedling establishment model will be developed using techniques and methods described in Franz and Bazzaz (1977), Rains et al. (2004), Henszey et al. (2004), Baird and Maddock (2005), and Maddock et al. (2012).
EXPECTED RESULTS
1. Probabilistic model of seedling establishment requirements based on GW/SW interaction model, sediment transport model, and ice regime model.

Table 4.4-1. Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation.

STUDY OBJECTIVES
1. Develop an integrated model of ice process interactions with floodplain vegetation. 2. Conduct primary research to identify the effects of ice on floodplain vegetation within mapped Susitna River ice floodplain impact zones. 3. Quantitatively describe and compare ice influenced and non-ice-influenced floodplain plant community composition, abundance, age, and spatial pattern to assess the role and degree of influence ice processes have on Susitna River floodplain vegetation. 4. Provide Project operational guidance on potential effects of operations flow on ice formation and floodplain vegetation development.
METHODS
1. Multiple lines of evidence will be used to inform a final research study design to address the question of vegetation response to ice shearing influence on the Susitna River floodplain. 2. First, ice vegetation impacts (tree ice-scars) will be observed, mapped, and aged (using dendrochronologic techniques), and gravel floodplain deposits will be mapped throughout the Study Area to develop a map of river ice floodplain vegetation interaction domains. 3. Local, sub-reach scale, floodplain vegetation ice disturbance effects were mapped and characterized in 2013. Additional forest scale ice disturbance effects will be characterized and sampled. 4. Interviews of local Susitna River residents concerning knowledge of ice dam locations and ice process effects. 5. Comparative quantitative vegetation study of ice effects on identified ice floodplain impact and un-impacted zones. Methods will build on those presented in Engstrom et al. (2011). 6. Integration of ice process modeling results with empirical ice vegetation mapping and ice vegetation interaction studies.
EXPECTED RESULTS
1. Ice processes domain and floodplain ice interaction geographic, and elevation, map to inform floodplain ice interaction vegetation study design and ice processes modeling, Section 7.6. 2. Develop a floodplain vegetation ice processes interaction study to compare ice disturbed and un-disturbed floodplains. The results of the study will be used to assess how floodplain vegetation pattern and process may change with Project operation alterations of the natural ice process regime. The final study design will be completed in Q2-3 2013, as additional tree ice-scar field data become available.

Table 4.5-1. Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils, and vegetation.

STUDY OBJECTIVES
1. Measure the rates of channel migration, and floodplain vegetation disturbance or turnover, throughout the Study Area. 2. Measure the rates of sediment deposition, and floodplain development, throughout the Study Area. 3. Assess / model how Project operations will effect changes in the natural sediment regime, floodplain depositional patterns, and soil development throughout the Study Area. 4. Assess / model how Project operations changes in sediment transport and soil development will affect floodplain plant community succession.
METHODS
1. Floodplain soils and stratigraphy will be sampled throughout the Study Area using a stratified random approach, including pits located in all Focus Areas. 2. Floodplain soil pits will be excavated from the surface to gravel / cobble layer (historic channel bed) and soil stratigraphy will be described and measured using standard NRCS field techniques (Schoeneberger et al. 2002). Standard sediment grain size sieve analysis will be conducted on the entire sediment profile. 3. Direct dating of fluvial sediments will be conducted using isotopic techniques, including, but not limited to, ^{137}Cs and ^{210}Pb measurements as described in Stokes and Walling (2003), Aalto (2003), and Aalto et al (2008). 4. Dendrochronologic techniques (Fritts 1976) will be used to age trees and current floodplain surfaces at each soil pit.
EXPECTED RESULTS
1. Dating of floodplain stratigraphy and surfaces using direct isotopic and dendrochronologic techniques for development of floodplain evolution model, 2. Floodplain stratigraphic descriptions and grain size analyses for development of floodplain evolution model and sediment transport modeling. 3. Measurement of rate of channel migration disturbance of floodplain vegetation. Measurement of rate of floodplain turnover or disturbance. 4. Model of how Project operations will effect soil development. 5. Model of alteration of riparian seedling establishment floodplain surfaces and floodplain vegetation succession.

Table 4.6-1. Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime.

STUDY OBJECTIVES

1. Characterize dominant floodplain woody plant species establishment and maintenance life stage water sources through stable isotope analyses of groundwater, soil water, and xylem water.
2. Measure groundwater and surface water regime at Focus Areas (GW: depth seasonally; SW: river stage)
3. Develop a floodplain GW/SW interaction model (water level frequency, magnitude, depth, duration, timing, interaction response).
4. Develop floodplain vegetation-flow response models.
5. Model Project operational flow effects on floodplain plant communities.

METHODS

1. Focus Area GW / SW sampling for sampled floodplain plant community types and successional stages including plant establishment, plant recruitment, and mature forest vegetation.
2. Sampling design will include transects and arrays of groundwater wells and surface water stage stations see Groundwater Study Section 7.5 for details.
3. Riparian floodplain plant community and soils sampling approach and design is detailed in the Riparian Vegetation Study Section 11.6.
4. Woody species source of water will be directly determined from stable isotope analyses of groundwater, soil water, precipitation, and xylem water hydrogen and oxygen.
5. The rooting depth of dominant floodplain plants will be measured through excavation of trenches within each Focus Area floodplain plant community type in coordination with soil stratigraphic excavations and well point soil pits.
6. Probabilistic response curves will be developed for select plant species and all riparian plant community types using techniques described in Rains et al. (2004) and Henszey et al. (2004).

EXPECTED RESULTS

1. Probabilistic response curves for select plant species and sampled riparian plant community types.
2. Floodplain vegetation-GW/SW regime functional groups.
3. Statistically modeled relationship between individual riparian species, floodplain plant community types, and natural GW/SW hydroregime.
4. Model of potential effects of Project operations on Susitna River floodplain plant communities.
5. Basis for recommended flow prescriptions necessary to support floodplain vegetation establishment, recruitment, and maintenance.

Table 4.7-1. Floodplain Vegetation Study Synthesis, Focus Area to Riparian Process Domain Model Scaling and Project Operations Effects Modeling.

STUDY OBJECTIVES
Study objectives are to: 1. Develop conceptual ecological model of Susitna River floodplain vegetation establishment and recruitment based on synthesis of Riparian Vegetation Study and Riparian IFS results. 2. Scale-up results of Focus Area floodplain vegetation and physical process modeling results to riparian process domains. 3. Develop a dynamic spatially-explicit floodplain vegetation model for simulating floodplain vegetation response to Project operation modification of the natural flow, sediment and ice processes regimes. 4. Develop spatially explicit maps of modeled Project operations effects throughout the Study Area. 5. Provide guidance to environmental analysis of Project operations.
METHODS
1. Develop a dynamic spatially-explicit floodplain vegetation model for simulating floodplain vegetation response to Project operation modification of the natural flow, sediment and ice processes regimes (Franz and Bazzaz 1976; Benjankar et al. 2011; Springer et al. 1999). 2. Fluvial Geomorphology Modeling Study 6.6, Ice Processes Study 7.6, and Groundwater Study 7.5 modeling studies will provide modeling results of both existing conditions and Project operation scenarios. 3. Riparian botanical forest succession models synthesis. 4. Floodplain vegetation (individual plant species and community types) GW/SW flow response curve analyses and physical process models (fluvial geomorphology, groundwater, ice processes) will be used to model floodplain vegetation transition dynamics at riparian process domain scale. 5. Focus Area modeling will be scaled-up to the riparian process domains using spatially explicit GIS models.
EXPECTED RESULTS
1. Conceptual ecological model of Susitna River floodplain vegetation establishment and recruitment floodplain vegetation. 2. Dynamic spatially-explicit floodplain vegetation model for simulating floodplain vegetation response to Project operation modification of the natural flow, sediment and ice processes regimes. 3. Riparian process domain scale model of floodplain vegetation and physical processes. 4. Spatially explicit maps of modeled Project operations floodplain vegetation effects throughout the Study Area. 5. Project operations guidance to minimize modeled floodplain vegetation effects.

Table 5.2-1. Riparian process domain #1 (RPD1).

Plant communities typed, and measured, along transects using Alaska Vegetation Classification (AVC) Level III (1992) community descriptions. First column describes communities identified along transects in RPD1 and remaining columns describe communities within Focus Areas in the riparian process domain. The sum of lengths (line-intercept sampling method; length in meters) for each cover type are reported in parentheses.

Plant Community	RPD1 (PRM 168.25-187)	FA-184 Watana Dam	FA-173 Stephan Lake Complex	FA-171 Stephan Lake Simple
Closed Conifer Forest	Yes (3625.5)	No	Yes (44.4)	Yes (134)
Open Conifer Forest	Yes (7080.3)	Yes (69.9)	Yes (407.9)	Yes (111)
Conifer Woodland	Yes (849.7)	Yes (105.4)	No	No
Closed Mixed Forest	Yes (2912)	Yes (81.1)	Yes (268.3)	Yes (314.1)
Open Mixed Forest	Yes (5567.7)	Yes (134.7)	Yes (746)	Yes (715.4)
Mixed Woodland	Yes (250.8)	No	Yes (77.7)	Yes (35.9)
Closed Broadleaf Forest	Yes (250.7)	Yes (8.5)	Yes (81.5)	No
Open Broadleaf Forest	Yes (329.4)	No	Yes (156.8)	Yes (13.1)
Broadleaf Woodland	Yes (31.3)	No	No	No
Closed Alder/Willow Shrub	Yes (750.9)	Yes (28.4)	Yes (246.9)	Yes (24.8)
Open Alder/Willow Shrub	Yes (585.6)	Yes (35)	Yes (155.5)	Yes (47)
Herbaceous	Yes (470.8)	No	Yes (47.4)	No
Partially Vegetated	Yes (228.4)	Yes (27.7)	Yes (119.7)	Yes (25.4)
Non-vegetation cover types[1]	Yes (16012.4)	Yes (810.8)	Yes (1857.3)	Yes (1164.2)
Total Transect Length	38945.4	1301.6	4209.4	2585.0
# of Plant Communities	13	8	11	9
percent Plant Communities overlap with RPD1	100 percent	62 percent	85 percent	69 percent

Notes:

1 Includes channel types (main channel, side channel, side slough, upland slough, etc.) as well as roads, and other human disturbances.

Table 5.2-2. Riparian process domain #3 (RPD3) plant communities typed, and measured, along transects using Alaska Vegetation Classification (AVC) Level III (1992) community descriptions.

First column describes communities identified along transects in RPD3 and remaining columns describe communities within Focus Areas in the riparian process domain. The sum of lengths (line-intercept sampling method; length in meters) for each cover type are reported in parentheses.

Plant Community	RPD3 (PRM 108-153.5)	FA-151 Portage Creek	FA-144 Side Channel 21	FA-141 Indian River	FA-138 Gold Creek	FA-128 Skull Creek Complex	FA-115 Lane Creek
Closed Conifer Forest	No	No	No	No	No	No	No
Open Conifer Forest	Yes (1243.9)	No	No	No	No	No	No
Conifer Woodland	Yes (307.6)	No	No	No	No	No	No
Closed Mixed Forest	Yes (5325.2)	No	Yes (20.8)	No	No	No	No
Open Mixed Forest	Yes (15444.3)	Yes (40.1)	Yes (30.4)	Yes (490.5)	Yes (257.6)	Yes (7.6)	Yes (322.6)
Mixed Woodland	Yes (6053.8)	No	Yes (125.5)	Yes (215.4)	Yes (73.7)	Yes (816.8)	Yes (233)
Closed Broadleaf Forest	Yes (10657.8)	No	Yes (645.7)	Yes (328)	Yes (1230)	Yes (307.9)	Yes (263)
Open Broadleaf Forest	Yes (17955.5)	Yes (9.5)	Yes (403.1)	Yes (140)	Yes (1271.9)	Yes (2240.5)	Yes (674.6)
Broadleaf Woodland	Yes (3480.4)	Yes (31.2)	No	No	No	Yes (61.9)	Yes (197.1)
Closed Alder/Willow Shrub	Yes (6008.8)	Yes (24)	Yes (232.9)	Yes (34.9)	Yes (439.5)	Yes (268.8)	Yes (21.5)
Open Alder/Willow Shrub	Yes (6188.6)	No	Yes (327.1)	Yes (330.9)	Yes (223.3)	Yes (307.1)	Yes (61.2)
Herbaceous	Yes (4138.2)	No	No	No	Yes (234.9)	Yes (21.3)	Yes (183.5)
Partially Vegetated	Yes (677)	No	Yes (10.6)	Yes (48.9)	Yes (50.9)	No	No
Non-vegetation cover types[1]	Yes (65375.2)	Yes (456)	Yes (2808.3)	Yes (2360.6)	Yes (1944.8)	Yes (3313.2)	Yes (2553.4)
Total Transect Length	142856	561	4604	3949	5727	7345	4510
# of Plant Communities	12	4	9	7	8	8	8
percent Plant Communities overlap with RPD3	100 percent	33 percent	75 percent	58 percent	67 percent	67 percent	67 percent

Notes:

1 Includes channel types (main channel, side channel, side slough, upland slough, etc.) as well as roads, and other human disturbances.

Table 5.2-3. Riparian process domain #4 (RPD4) plant communities typed, and measured, along transects using Alaska Vegetation Classification (AVC) Level III (1992) community descriptions.

First column describes communities identified along transects in RPD4 and remaining columns describe communities within Focus Areas in the riparian process domain. The sum of lengths (line-intercept sampling method; length in meters) for each cover type are reported in parentheses.

Plant Community	RPD4 (PRM 104-107.75)	Whiskers Slough
Closed Conifer Forest	No	No
Open Conifer Forest	Yes (557.3)	Yes (71.5)
Conifer Woodland	Yes (87)	No
Closed Mixed Forest	Yes (5285.1)	Yes (109.6)
Open Mixed Forest	Yes (20752.7)	Yes (10185.8)
Mixed Woodland	Yes (2727.7)	Yes (820)
Closed Broadleaf Forest	Yes (2776.5)	Yes (994.1)
Open Broadleaf Forest	Yes (1328.1)	Yes (831.1)
Broadleaf Woodland	Yes (607.7)	Yes (180.5)
Closed Alder/Willow Shrub	Yes (320.5)	Yes (313.6)
Open Alder/Willow Shrub	Yes (508.9)	Yes (185.3)
Herbaceous	Yes (2198.3)	Yes (770.3)
Partially Vegetated	Yes (290.3)	Yes (100)
Non-vegetation cover types[1]	Yes (7020.7)	Yes (2848.1)
Total Transect Length	44461	17410
# of Plant Communities	12	11
percent Plant Communities overlap with RPD4	100 percent	92 percent

Notes:

1 Includes channel types (main channel, side channel, side slough, upland slough, etc.) as well as roads, and other human disturbances.

Table 5.2-4. Rationale for Riparian IFS Focus Area selection

Focus Area ID	Common Name	Riparian IFS	Riparian IFS Selection Rationale
Focus Area-184	Watana Dam		Not-selected. Floodplain vegetation occurs on only a few mid-channel island bars. Non-focus area vegetation sampling will be conducted in these areas.
Focus Area-173	Stephan Lake, Complex Channel	X	Focus Area captures the diversity of floodplain vegetation types in the upper moderately confined riparian process domain from the dam site to Devils Canyon.
Focus Area-171	Stephan Lake, Simple Channel		Not-selected. Approximately 0.5 miles south of FA-173. Similar vegetation types but less floodplain terrain complexity.
Focus Area-151	Portage Creek		Not-selected. Steep valley walls immediately adjacent to channel. Floodplain vegetation is minimal.
Focus Area-144	Side Channel 21		Not-selected. Process domain representative vegetation, however, lacking in off-channel water body and wetland complexity.
Focus Area-141	Indian River		Not selected. Very limited floodplain area.
Focus Area-138	Gold Creek	X	Representative floodplain vegetation types and river right beaver dam wetland complex.
Focus Area-128	Skull Creek Complex	X	Representative floodplain vegetation types and complex off-channel water bodies and associated wetlands.
Focus Area-115	Lane Creek	X	Representative floodplain vegetation types and off-channel water bodies associated with beaver dam wetland complex.
Focus Area-104	Whiskers Slough	X	Transition riparian process domain between, Three Rivers confluence and moderately confined riparian process domain. Representative floodplain vegetation types and off-channel water bodies and associated beaver dam wetland complexes.

Table 5.2-5. List of Focus Areas selected for Riparian-IFS studies within each Riparian Process Domain.

Middle River Riparian Process Domain	Location (PRM)		Associated Riparian-IFS Focus Areas			
					Location (PRM)	
	Upstream	Downstream	Focus Area ID	Common Name	Upstream	Downstream
RPD1	187	168.25	Focus Area-173	Stephan Lake, Complex Channel	175.4	173.6
RPD2	168	153.75	None	N/A	N/A	N/A
RPD3	153.5	108	Focus Area-138	Gold Creek	140	138.7
			Focus Area-128	Skull Creek Complex	129.7	128.1
			Focus Area-115	Lane Creek	116.5	115.3
RPD4	107.75	104	Focus Area-104	Whiskers Slough Complex	106	104.8

Table 5.3-1. Number and species of *Salix* and *Populus* surveyed at each of four seed release study sites located in the Lower and Middle Segments on the Susitna River.

PRM (Site Name)	Number of Shrubs	Shrub Species	Number of Trees	Tree Species
PRM 47 (Deshka Landing)	6 6	*Salix alaxensis* *Salix barclayi*	6	*Populus balsamifera*
PRM 88 (Parks Highway Bridge)	5 1	*Salix alaxensis* *Salix sitchensis*	6	*Populus balsamifera*
PRM 102 (Talkeetna)	6	*Salix barclayi*	6	*Populus balsamifera*
PRM 142 (Indian River)	5 7	*Salix alaxensis* *Salix sitchensis*	6	*Populus balsamifera*

Table 5.3-2. Day of year when plants have released 20 percent (DY_{20}) and 80 percent (DY_{80}) of seeds based on 2013 data.

Values are averaged by site and species for site/species combinations with >3 plants having estimable quantiles. (Julian Day 170 = June 19)

PRM (Site Name)	Tree or Shrub Species	Number of Plants	DY20	DY80	Peak Seed Release Duration
PRM 47 (Deshka Landing)	*Populus balsamifera*	6	170	177	7
PRM 88 (Parks Highway Bridge)	*Populus balsamifera*	6	170	179	9
PRM 102 (Talkeetna)	*Populus balsamifera*	6	171	179	7
PRM 142 (Indian River)	*Populus balsamifera*	6	173	180	7
PRM 47 (Deshka Landing)	*Salix barclayi*	6	170	198	29
PRM 88 (Parks Highway Bridge)	*Salix alaxensis*	3	164	188	25
PRM 102 (Talkeetna)	*Salix barclayi*	6	172	201	28
PRM 142 (Indian River)	*Salix sitchensis*	5	166	182	17

Table 5.3-3. Distribution of seedling establishment transects by Focus Area and geomorphic position.

	Focus Area					
Geomorphic Position	**FA-104**	**FA-113**	**FA-128**	**FA-138**	**FA-144**	**Total Transects**
Island Head		2				**2**
Island Tail				2		**2**
Main Channel					4	**4**
Slough		6	6		2	**14**
Slough-Main Channel Confluence		2	2			**4**
Side Channel	5	2		2		**9**
Total	**5**	**12**	**8**	**4**	**6**	**35**

Table 5.3-4. Overview of spruce recruitment transect observations.

Transect Island (PRM)	Transect Number	Transect Length (m)	Transect Area (ha)	percent of Island in Survey Area	Number of Spruce Snags	Number of Spruce Trees >1.4 m tall	Number of Spruce <1.4 m tall	Average Tree (>1,4 m tall) DBH (cm ± SD)	Average Tree Height (m ± SD)	Average Seedling Spruce Height (m ± SD)	Min-Max Height (m)
105.1	1	210	0.17	6 percent	0	6	0	17.52 ± 7.98	10.25 ± 5.12	None	2.50 – 15
112.5	1	173	0.14	12 percent	2	27	3	11.63 ± 6.72	8.63 ± 4.11	0.55 ± 0.30	0.37 – 15
115.3	1	228	0.18	18 percent	0	2	0	12.40 ± 8.91	9.00 ± 7.07	None	4.00 – 14
115.3	2	260	0.21		3	18	0	18.56 ± 7.64	11.50 ± 3.85	None	3.00 – 16
114.5	1	315	0.25	10 percent	0	15	3	5.45 ± 3.16	3.90 ± 2.32	0.90 ± 0.52	0.53 – 8
114.5	2	322	0.26		1	44	3	7.02 ± 4.08	6.03 ± 3.64	0.75 ± 0.48	0.46 – 17
115.6	1	930	0.74	10 percent	6	27	0	22.29 ± 8.17	15.56 ± 5.04	None	5.50 - 25
115.6	2	980	0.78		1	14	0	25.14 ± 7.66	19.64 ± 3.71	None	13.00 - 24
128.1	1	280	0.22	19 percent	0	27	5	2.42 ± 1.39	2.53 ± 0.88	0.67 ± 0.25	0.30 - 4.5
128.1	2	258	0.21		0	5	30	2.08 ± 1.25	2.17 ± 0.79	0.60 ± 0.27	0.22 - 3.5
135	1	288	0.23	5 percent	0	11	84	2.09 ± 1.76	1.89 ± 0.55	0.80 ± 0.29	0.20 - 3.4
135	2	150	0.12		0	0	99	None	None	0.65 ± 0.23	0.10 - 1.3

Table 5.3-5. Trees sampled on spruce transect islands.

Island (PRM)	Total number of Spruce Cored/Cookied	Number of Spruce Sampled for Sediment	Average Depth of Root Collar Burial (cm ± SD)	Min - Max Depth of Root Collar Burial (cm)	Average Depth to Armor (cm ± SD)	Min - Max Depth to Armor (cm)	Average Number of Organic Layers in First 30 cm (± SD)
105.1	5	5	5.33 ± 11.24	-7 - 15	119.60 ± 5.64	110 - 123	3.80 ± 0.84
112.5	8	6	3.67 ± 3.93	0-9	78.50 ± 17.36	57 - 97	3.33 ± 0.82
115.3	8	6	7.67 ± 5.92	-3 - 13	87.58 ± 13.69	78 - 108	4.33 ± 1.86
114.5	6	10	11.33 ± 16.29	0 - 30	86.09 ± 10.50	72 - 108	3.27 ± 0.90
115.6	12	10	-3.63 ± 17.32	-31 - 25	81.29 ± 18.42	42 - 98	2.20 ± 0.63
128.1	7	7	13.00 ± 5.60	5 - 21	43.29 ± 15.86	28 - 76	2.57 ± 0.77
135	6	5	11.20 ± 7.46	6 - 24	72.00 ± 4.18	67 - 76	1.80 ± 0.84

Table 5.5-1. Stem number and mean DBH for trees and selected shrubs at ITU sample plots.

			Trees			Shrubs		
Preliminary Viereck Classification	**Focus Area**	**Site**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**
Balsam Poplar Woodland	115	115-0813-KLBD-S3	10	34.5	56.7	None	None	None
Bluejoint Meadow	104	104-0815-KLBD-S4	2	5.7	0.4	55	1.4	0.8
	115	115-070213-KKKLBD-S1	39	6.7	1.9	100	2.0	1.0
		115-070213-KKKLBD-S2	7	13.5	19.5	24	1.5	0.9
	115 Total		46	7.7	7.3	124	1.9	1.0
Closed Balsam Poplar	104	104-0626-KKKF-S2	30	31.8	15.9	27	2.4	1.0
		104-0626-KKKF-S3	50	21.6	11.0	32	2.5	1.2
		104-062713-KKKLBD-S2	26	23.2	24.5	14	2.3	1.5
		104-062813-KKKLBD-S3	13	29.5	33.7	4	4.8	0.5
		104-062913-KLMMBD-S3	28	21.9	24.3	None	None	None
		104-063013-KKKLBD-S3	24	34.9	19.5	None	None	None
	104 Total		171	26.2	19.7	77	2.5	1.2
	115	115-070213-KKKLBD-S4	43	20.3	7.1	104	1.2	0.6
		115-070213-KKKLBD-S5	45	20.1	10.4	53	1.3	0.5
		115-0828-KFBD-S1	29	15.0	17.6	11	3.0	1.3
		115-0907-KKKL-S1	31	22.4	27.4	15	3.7	1.2
	115 Total		148	19.6	16.0	183	1.6	0.7

			Trees			Shrubs		
Preliminary Viereck Classification	**Focus Area**	**Site**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**
Closed Poplar Woodland--Alder Tall Shrub	104	104-0626-KKKF-S1	None	None	None	215	2.0	0.0
		104-062713-KKKLBD-S1	None	None	None	317	1.6	0.6
		104-063013-KKKLBD-S5	None	None	None	247	2.2	0.8
	104 Total		-	-	-	779	1.9	0.6
Closed Tall Alder-Willow	115	115-070213-KKKLBD-S6	2	6.4	0.5	179	2.4	1.0
Closed Tall Willow	128	128-0817-KFMMBD-S2	2	5.9	0.4	175	2.3	1.1
Ferns	104	104-062913-KLMMBD-S2	26	8.2	2.3	24	1.8	1.2
		104-0808-KKKLBD-S3	12	12.9	14.2	6	2.0	0.6
	104 Total		38	9.7	7.9	30	1.8	1.0
	115	115-0813-KLBD-S2	2	15	0	None	None	None
Open Balsam Poplar Forest	104	104-0815-KLBD-S1	11	47.3	41.8	None	None	None
	115	115-0809-KKKLBD-S3	17	37.4	20.1	3	1.3	0.6
		115-0809-KKKLBD-S4	5	41.0	26.2	None	None	None
		115-0813-KLBD-S4	9	33.9	43.9	None	None	None
		115-0813-KLBD-S5	21	10.9	5.6	4	2.3	0.5
		115-0814-KLBD-S1	5	86.0	15.6	None	None	None
		115-0814-KLBD-S2	4	36.4	41.5	8	1.6	0.5
	115 Total		61	32.0	22.7	15	1.7	0.5
	128	128-0817-KFMMBD-S1	33	19.1	12.8	28	2.3	1.0
		128-0817-KFMMBD-S4	8	30.2	37.9	21	3.9	1.0
		128-0913-KKF-S1	44	10.7	5.0	79	2.1	1.3
	128 Total		85	15.8	13.9	128	2.4	1.2

			Trees			Shrubs		
Preliminary Viereck Classification	**Focus Area**	**Site**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**
Open Poplar Woodland-Alder-Willow Tall Shrub	115	115-0818-MMBD-S2				611	1.7	0.7
Open Spruce-Balsam Poplar Forest	104	104-063013-KKKLBD-S4	25	15.1	17.4	20	3.7	1.3
		104-0808-KKKLBD-S1	3	36.6	21.0	None	None	None
	104 Total		28	17.4	17.1	20	3.7	1.3
	128	128-0817-KFMMBD-S3	10	38.7	39.1	9	3.8	0.8
Open Spruce-Paper Birch	104	104-062813-KKKLBD-S1	61	9.3	8.4	None	None	None
		104-062813-KKKLBD-S2	20	20.8	11.5	35	2.6	1.0
		104-062913-KLMMBD-S1	18	22.7	11.4	None	None	None
		104-0808-KKKLBD-S2	8	20.0	15.2	4	3.5	0.6
		104-0815-KLBD-S2	30	14.7	11.3	3	3.7	1.2
		104-0815-KLBD-S3	19	23.8	15.2	2	4.0	0.0
		104-0816-MMBD-S1	8	14.0	16.1	None	None	None
	104 Total		164	15.6	11.1	46	0.7	0.3
	115	115-0814-KLBD-S5	3	28.8	8.4	None	None	None
Spruce-Balsam Poplar Woodland	104	104-063013-KKKLBD-S1	31	13.2	10.0	15	3.7	1.5
		104-063013-KKKLBD-S2	33	10.5	9.8	26	3.5	1.2
	104 Total		64	11.8	9.7	41	3.5	1.3
	115	115-0809-KKKLBD-S1	52	9.0	7.0	34	3.5	1.3
		115-0809-KKKLBD-S2	4	78.6	40.5	None	None	None
		115-0813-KLBD-S1	3	7.5	1.0	None	None	None
	115 Total		59	13.7	11.2	34	3.5	1.3

			Trees			Shrubs		
Preliminary Viereck Classification	**Focus Area**	**Site**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**	**Number of Stems**	**Mean DBH (cm)**	**Standard Deviation (cm)**
Spruce-Paper Birch Woodland	115	115-0814-KLBD-S3	40	13.0	10.5	78	2.2	1.3
		115-0814-KLBD-S4	36	8.2	4.9	261	1.9	1.2
	115 Total		76	10.7	8.3	339	2.0	1.2

Table 5.6-1. Number of plant isotope samples collected by sample site and plant community structural type.

	Plant Community Structural Type			
Sample Period	**Herbaceous**	**Shrub**	**Tree**	**Total**
FA-104				
June (Leaf-Out)	37	10	48	95
July (Mid-Summer)	34	38	35	107
September (Late-Summer)	35	50	30	115
Total FA-104	**106**	**98**	**113**	**317**
FA-128				
June (Leaf-Out)	39	20	50	109
July (Mid-Summer)	55	43	25	123
September (Late-Summer)	45	45	20	110
Total FA-128	**139**	**108**	**95**	**342**
Grand Total	**245**	**206**	**208**	**659**

Table 5.6-2. Number of soil isotope samples by canopy cover type.

	Number of Isotope Samples by Site	
Canopy Cover Type	**FA-104**	**FA-128**
Alder/Willow	55	52
Poplar	29	116
Poplar/Spruce	42	65
Spruce/Birch	53	0
Old Spruce/Birch	55	0
Poplar/Alder	0	13
Open Alder	0	65
Total Samples	**234**	**311**

Table 5.6-3. Number of water isotope samples by site, month, and water source.

	Number of Water Isotope Samples			
Water Source	**June (Leaf-out)**	**July (Mid-summer)**	**September (Late summer)**	**Total**
FA-104				
Groundwater	0	0	8	8
Main Channel	1	3	2	6
Precipitation	0	8	9	17
Slough	2	3	2	7
FA104 Total	**3**	**14**	**21**	**38**
FA-128				
Groundwater	0	0	4	4
Precipitation	0	9	14	23
Side Channel	0	2	2	4
Slough	4	5	4	13
FA-128 Total	**4**	**16**	**24**	**44**
Talkeetna				
Precipitation	2	2	14	18
Grand Total	**9**	**32**	**59**	**100**

Table 5.6-4. Number and species of trees and shrubs with sap flow instrumentation at each riparian GW/SW station.

	Species					
Station ID	***Alnus incana* ssp. *tenuifolia***	***Betula papyrifera***	***Picea glauca***	***Populus balsamifera***	***Salix* spp.**	**Total**
ESGFA104-4		3	3			6
ESGFA104-6	2				2	4
ESGFA104-7			1	3		4
ESGFA104-8		3	3			6
ESGFA128-3	2				2	4
ESGFA128-5		2	3	1		6
ESGFA128-9	3				2	5
ESGFA128-10				3		3
Total	**7**	**8**	**10**	**7**	**6**	**38**

Table 5.6-5. List of species sampled for stomatal conductance at each Focus Area.

Note: All species scientific names are consistent with current nomenclature listed at plants.usda.gov, common names follow Viereck et al (1992) and Hulten (1968).

Species		Focus Area			
Scientific Name	**Common Name**	**FA 104**	**FA 115**	**FA 128**	**Total**
Trees					
Populus balsamifera	balsam poplar	13	0	8	21
Betula papyrifera	paper birch	10	0	12	22
Picea glauca	white spruce	18	0	18	36
Shrubs					
Sambucus racemosa	red elderberry	8	0	0	8
Alnus sinuata	Sitka alder	0	0	1	1
Alnus viridis ssp. *crispa*	mountain alder	186	21	98	305
Alnus incana ssp. *tenuifolia*	thinleaf alder	91	54	72	217
Rosa acicularis	Arctic rose	121	94	52	267
Salix barclayi	Barclay's willow	113	10	85	208
Salix bebbiana	Bebb willow	0	0	37	37
Salix alaxensis	feltleaf willow	48	2	57	107
Viburnum edule	highbush cranberry	162	56	154	372
Rubus idaeus	American red raspberry	26	15	60	101
Ribes triste	red currant	78	2	68	148
Herbs					
Calamagrostis canadensis	bluejoint	170	121	115	406
Heracleum lanatum	common cowparsnip	108	57	96	261
Delphinium glaucum	Sierra larkspur	8	0	12	20
Oplopanax horridus	devils club	88	7	58	153
Dryopteris expansa	spreading woodfern	10	5	4	14
Chamerion angustifolium ssp. *angustifolium*	fireweed	84	83	92	259
Gymnocarpium dryopteris	western oakfern	2	0	12	14
Matteuccia struthiopteris	ostrich fern	185	64	114	363
Streptopus amplexifolius	watermelon berry	77	0	53	130
Trientalis europaea	arctic starflower	20	0	6	26
Carex spp.	sedge species	11	88	2	101
Total		**1637**	**679**	**1286**	**3602**

Table 5.6-6. Number of stomatal conductance measurements by sampling location, sample period, and plant community structural type.

	Plant Community Structural Type			
Sampling Month	**Herbaceous**	**Shrub**	**Tree**	**Total**
June	**715**	**747**	**71**	**1533**
FA-104	478	524	41	1043
FA-128	237	223	30	490
July	**1016**	**1011**	**8**	**2035**
FA-104	285	309	0	594
FA-115	425	254	0	679
FA-128	306	448	8	762
September	**12**	**22**	**0**	**34**
FA-128	12	22	0	34
Total	**1743**	**1779**	**79**	**3602**

10. FIGURES

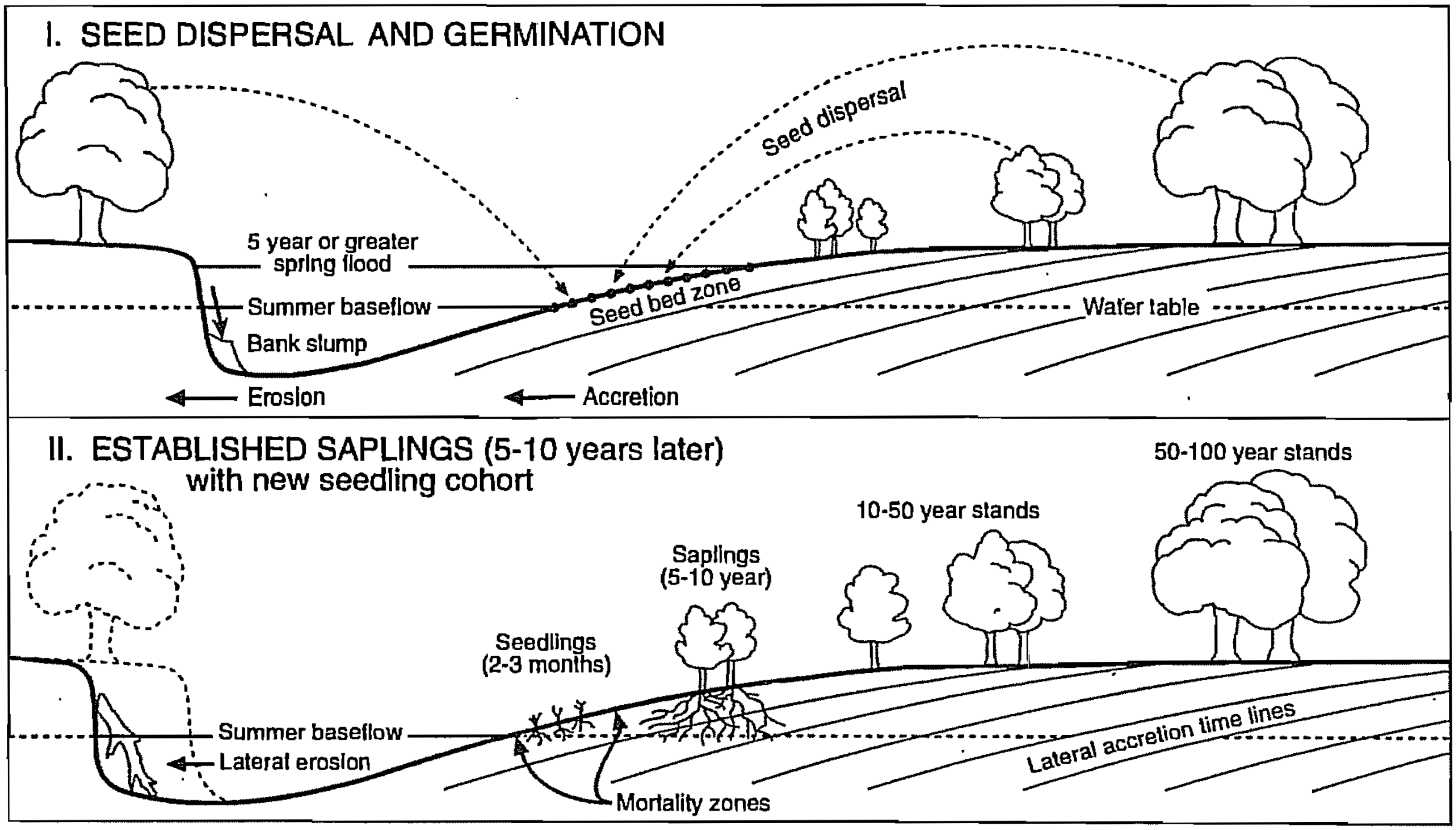


Figure 4.3-1. Cottonwood (Populus) life history stages: seed dispersal and germination, sapling to tree establishment. Cottonwood typically germinates on newly created bare mineral soils associate with lateral active channel margins and gravel bars. Note proximity of summer baseflow and floodplain water table (Braatne et al. 1996).

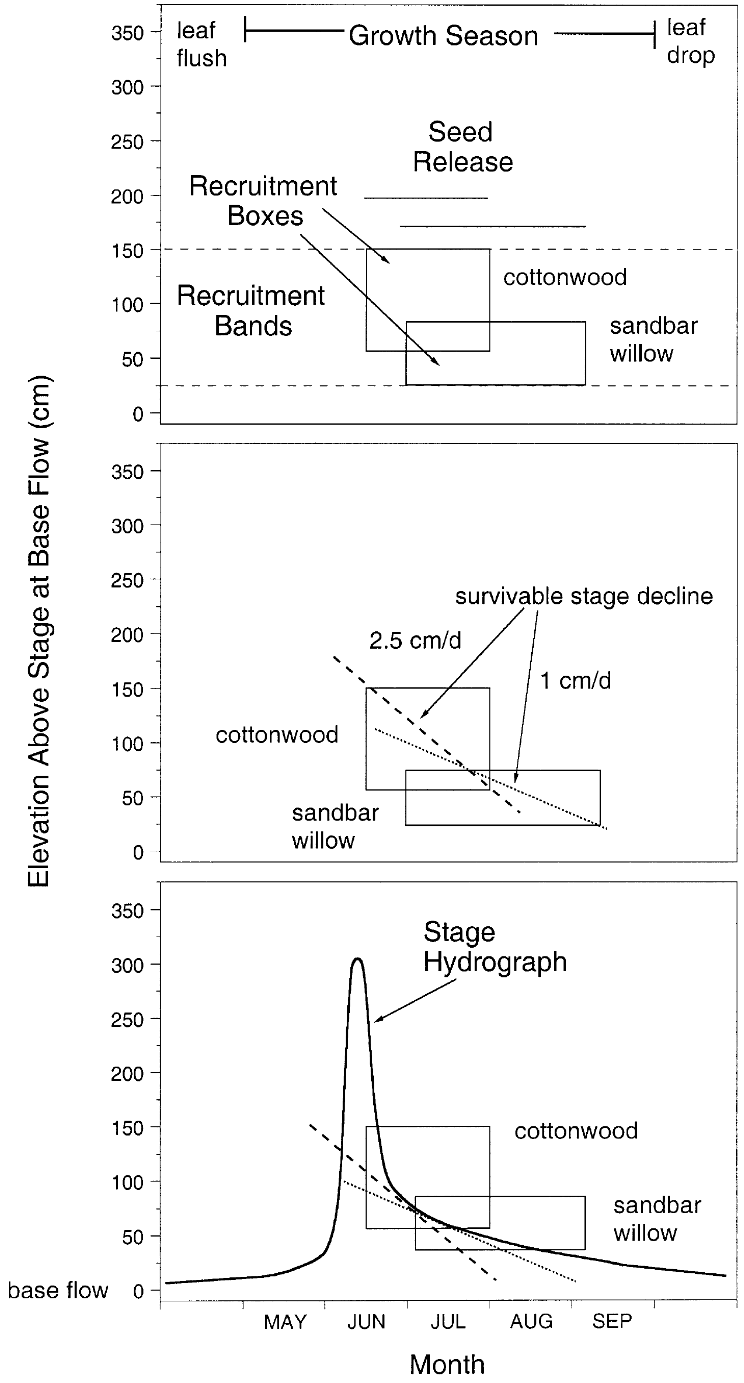


Figure 4.3-2. The riparian "Recruitment Box Model" describing seasonal flow pattern, associated river stage (elevation), and flow ramping necessary for successful cottonwood and willow seedling establishment (from Amlin and Rood 2002; Rood et al. 2005).

Stage hydrograph and seed release timing will vary by region, watershed, and plant species. Cottonwood species is *Populus deltoides*, willow species is *Salix exigua*.

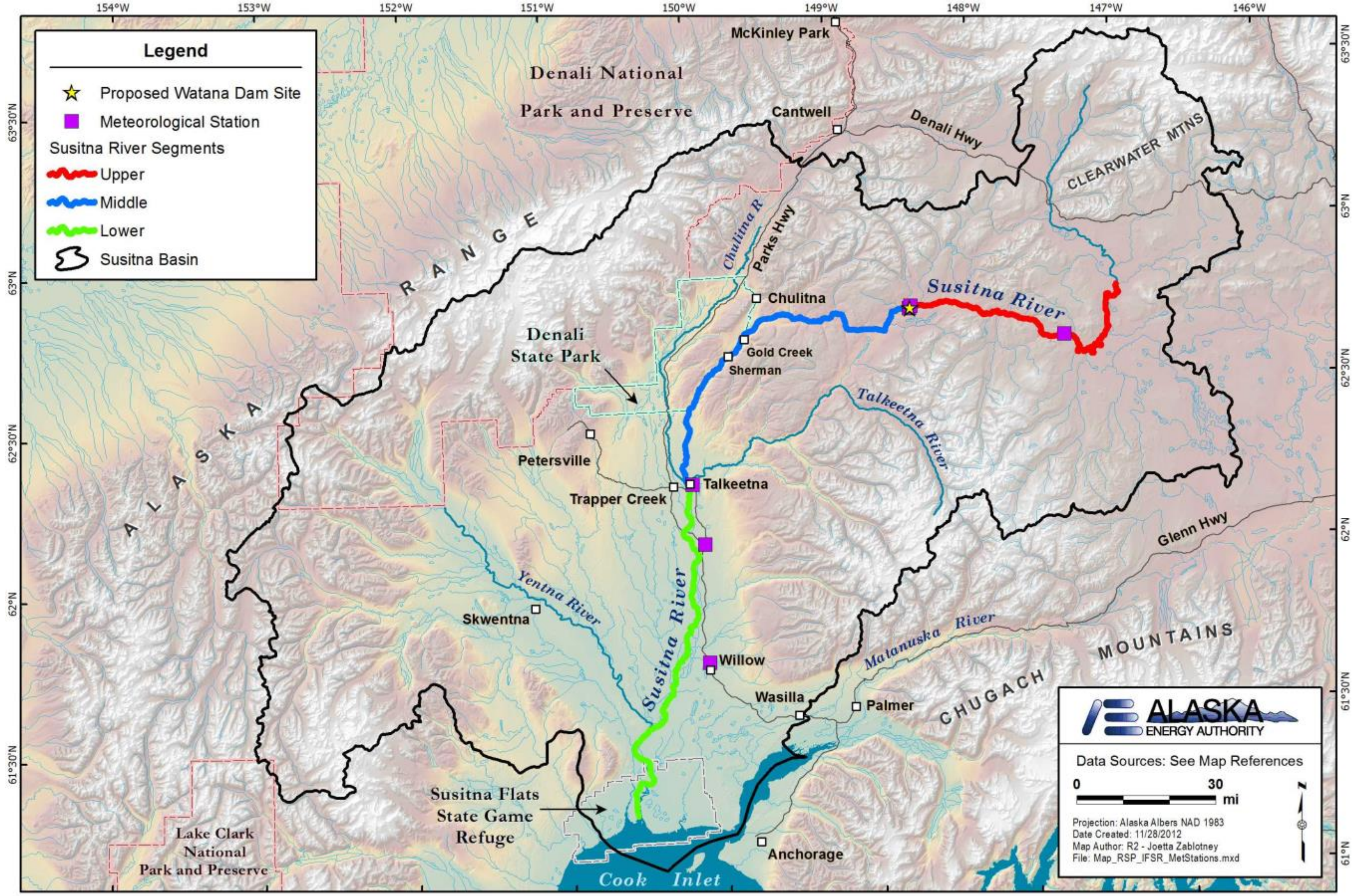


Figure 4.3-3. Susitna Project area meteorological station locations.

Figure 4.4-1. Balsam poplar tree ice-scar. Floodplain located immediately above Three Rivers Confluence.

Figure 4.4-2. Balsam poplar forest tree ice-scars. Floodplain located immediately above Three Rivers Confluence.

Figure 4.4-3. Floodplain ice deposited gravel piles. Floodplain in braided reach below Three Rivers Confluence.

Figure 4.4-4. Tree ice scar wedge (Picea glauca, white spruce).

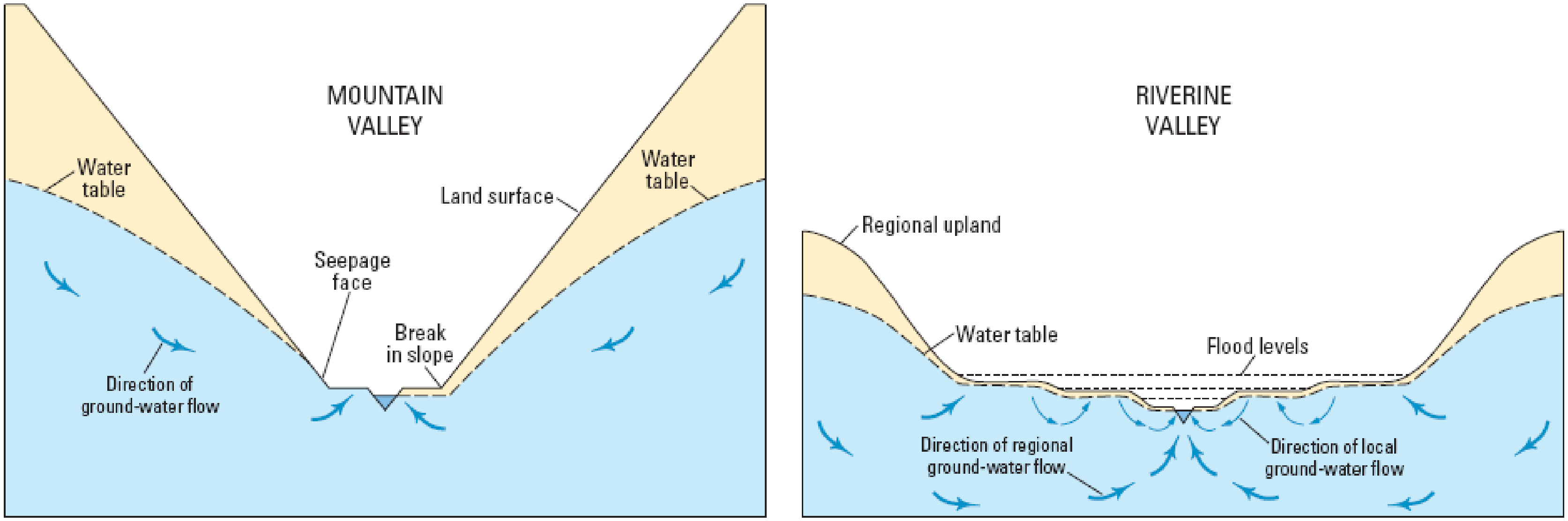


Figure 4.6-1. Riverine hydrologic landscape (Winter 2001).

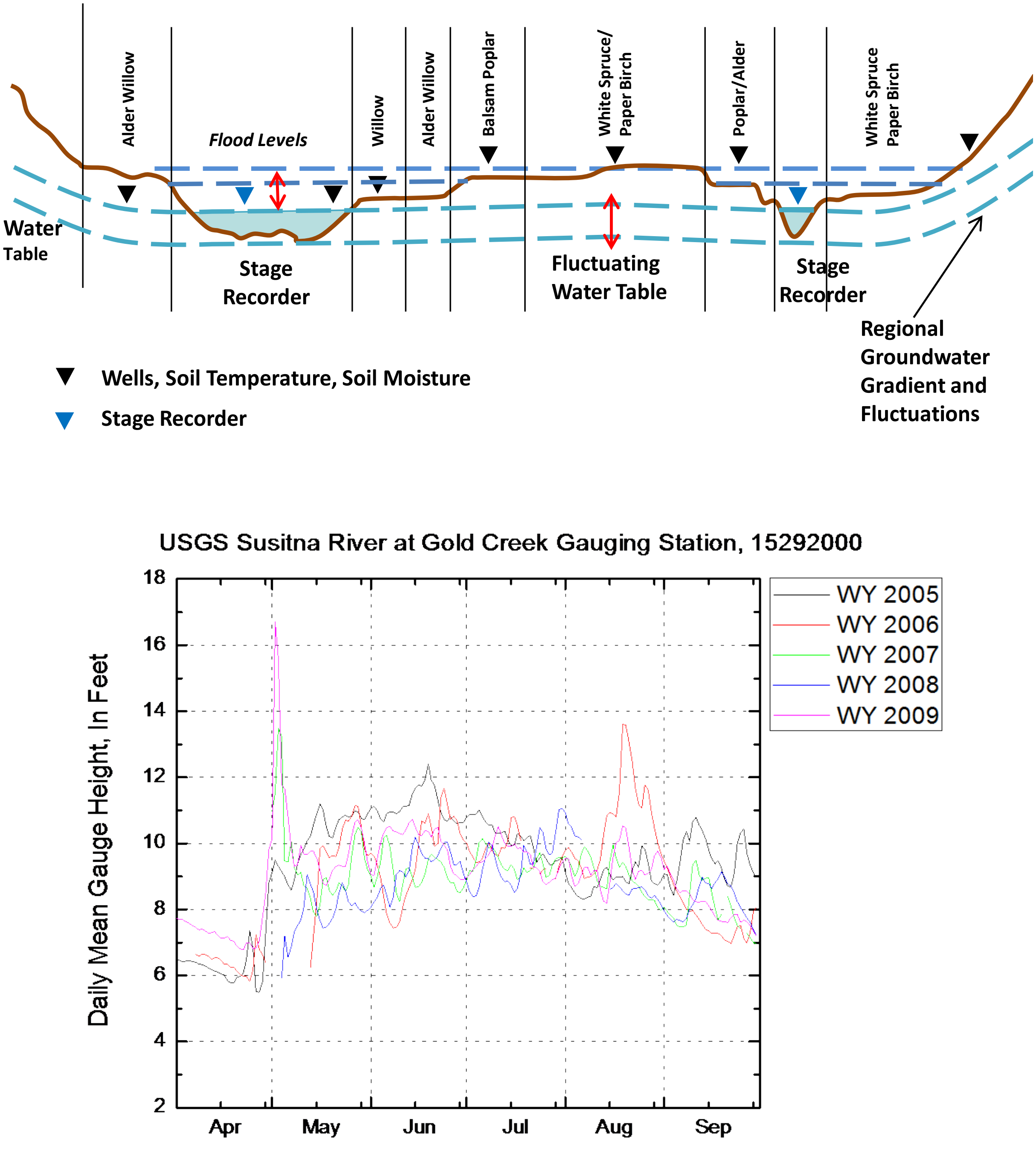


Figure 4.6-2. (A) Transect profile view of typical monitoring well and stage recorder locations looking down river. (B) Gold Creek Gauge Station, Susitna River April through September 2005-2009.

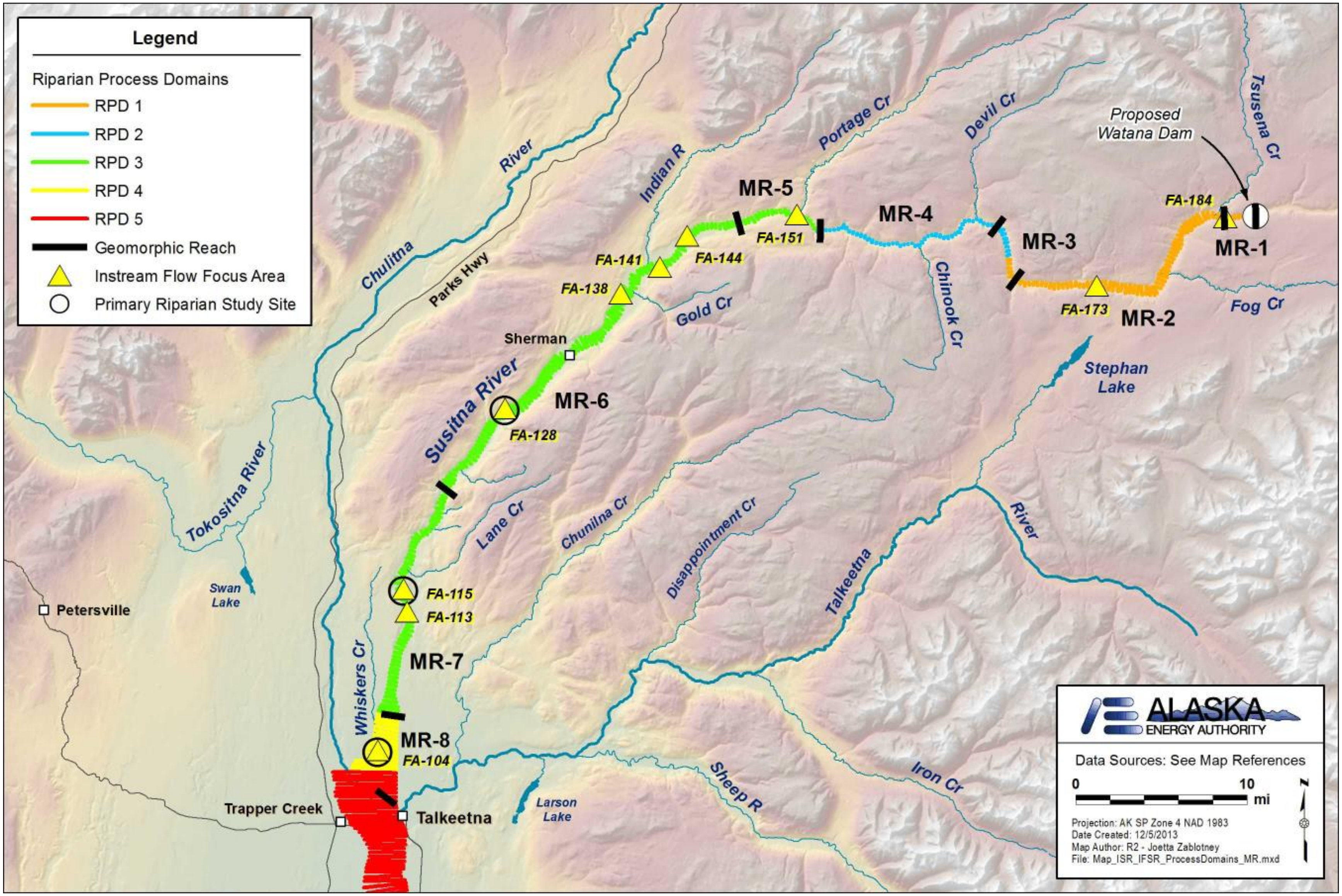


Figure 5.2-1. Riparian Process Domains on the Middle River with locations of associated Riparian IFS Focus Areas.

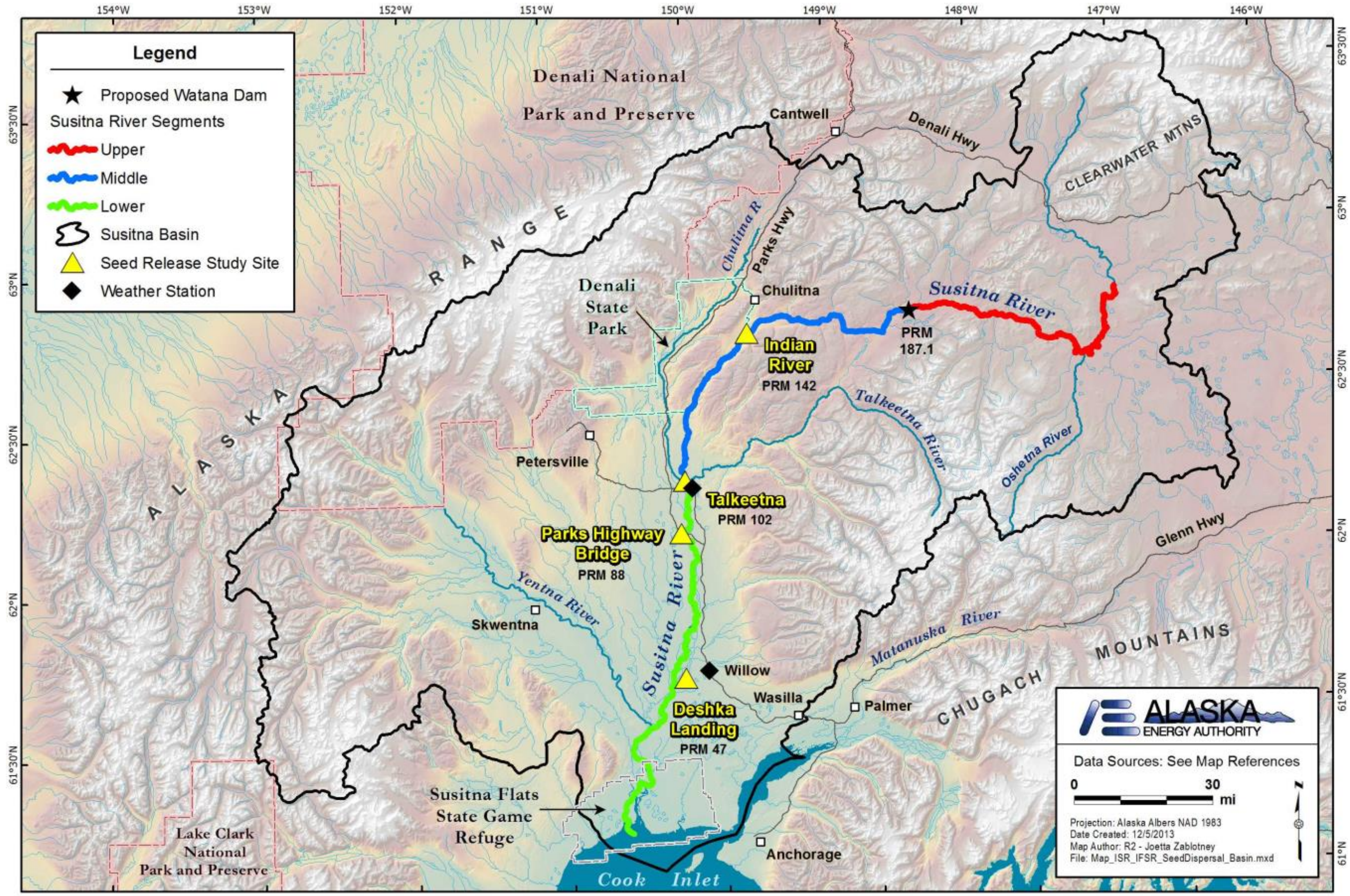


Figure 5.3-1. Location of four seed release sites surveyed in 2013 on the Susitna River.

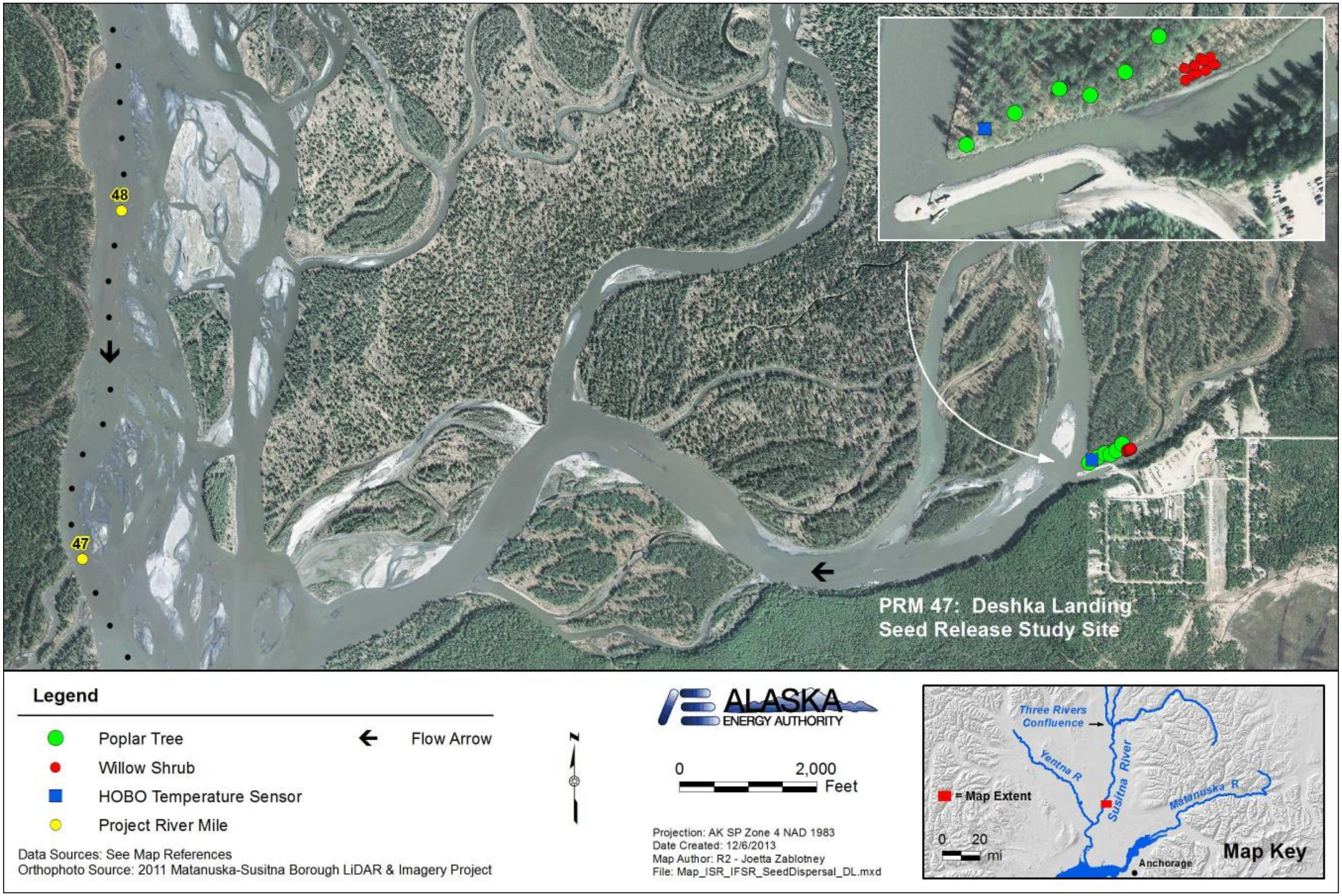


Figure 5.3-2. Seed Dispersal Study Site at PRM 47: Deshka Landing

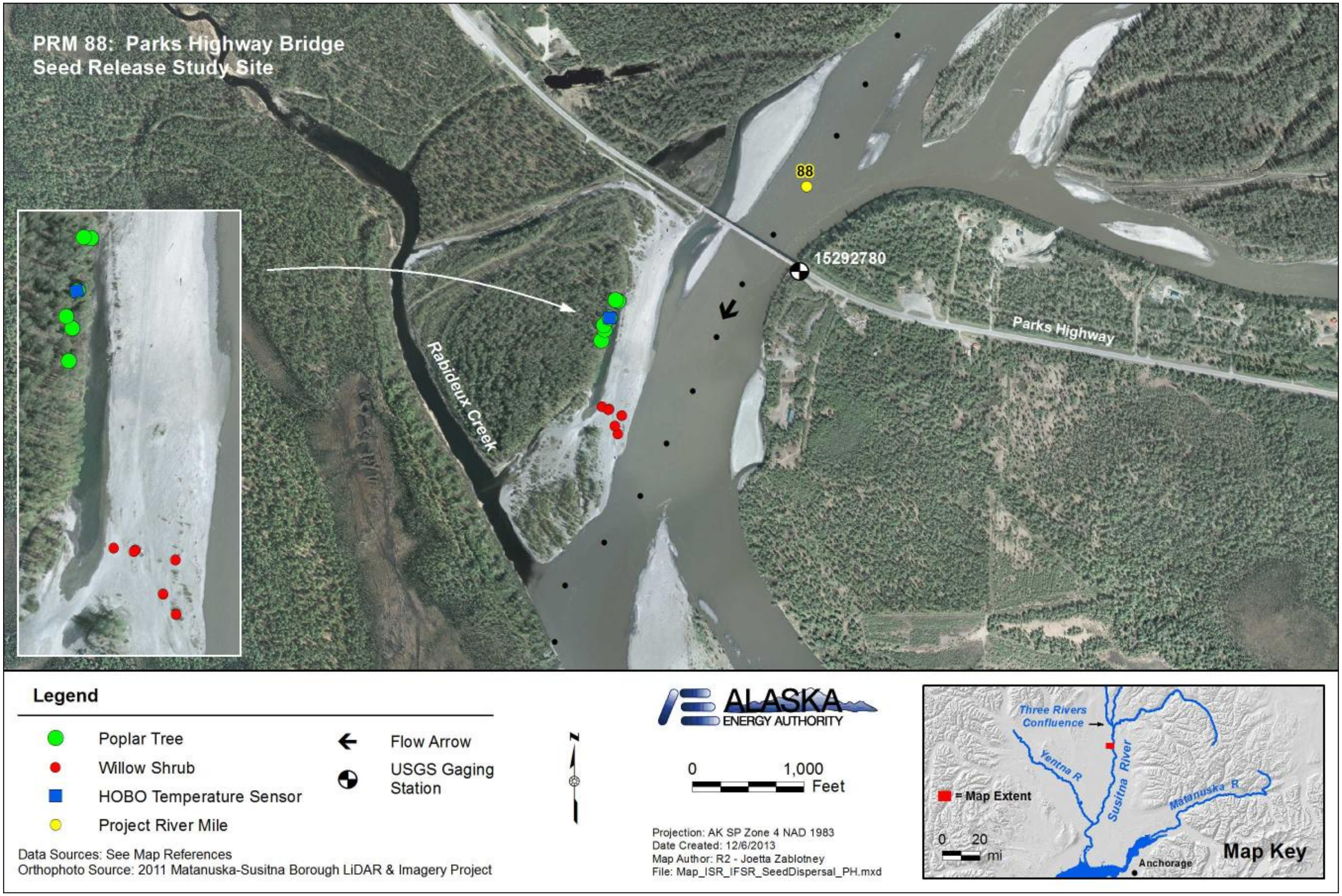


Figure 5.3-3. Seed Dispersal Study Site at PRM 88: Parks Highway Bridge.

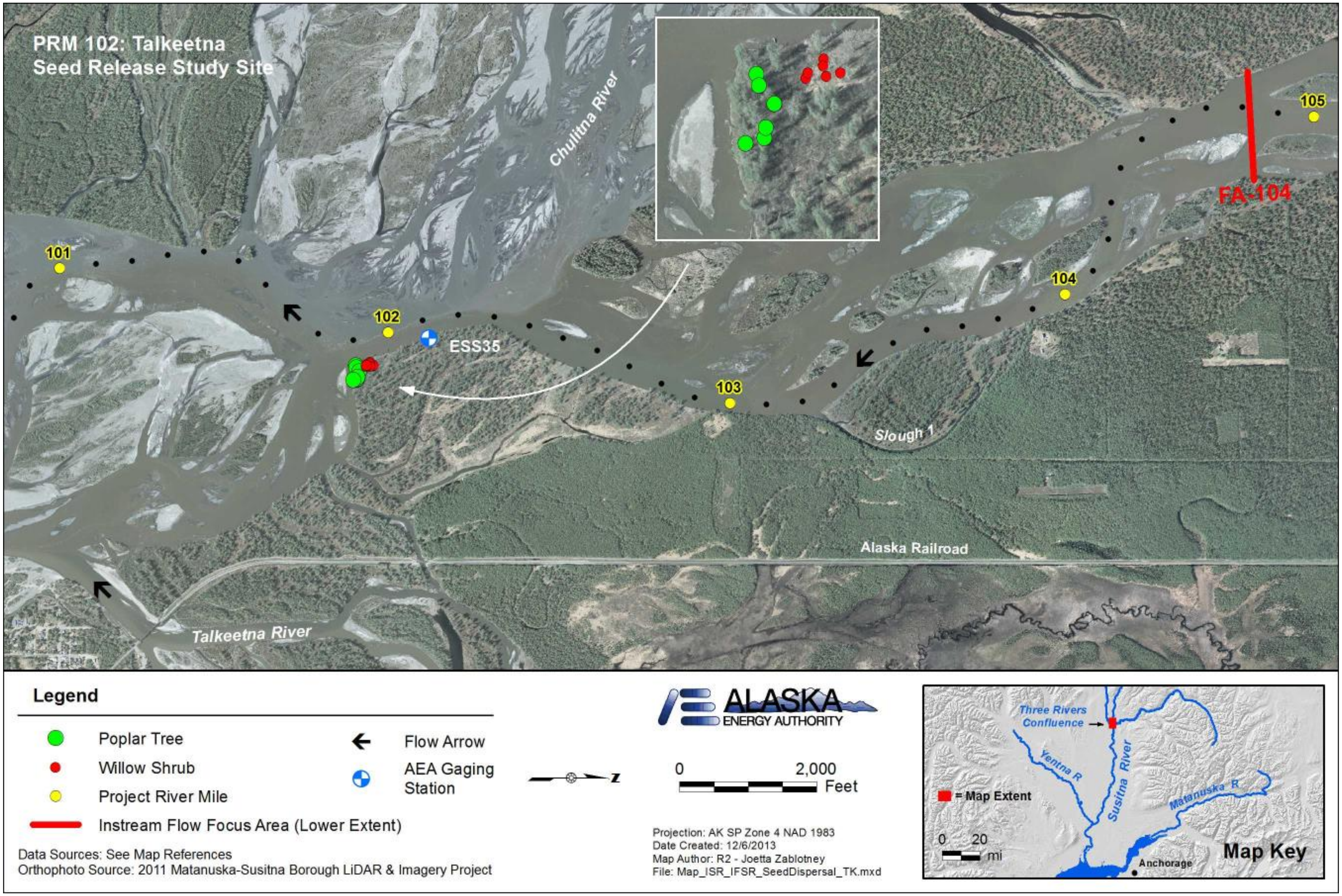


Figure 5.3-4. Seed Dispersal Study Site at PRM 102: Talkeetna

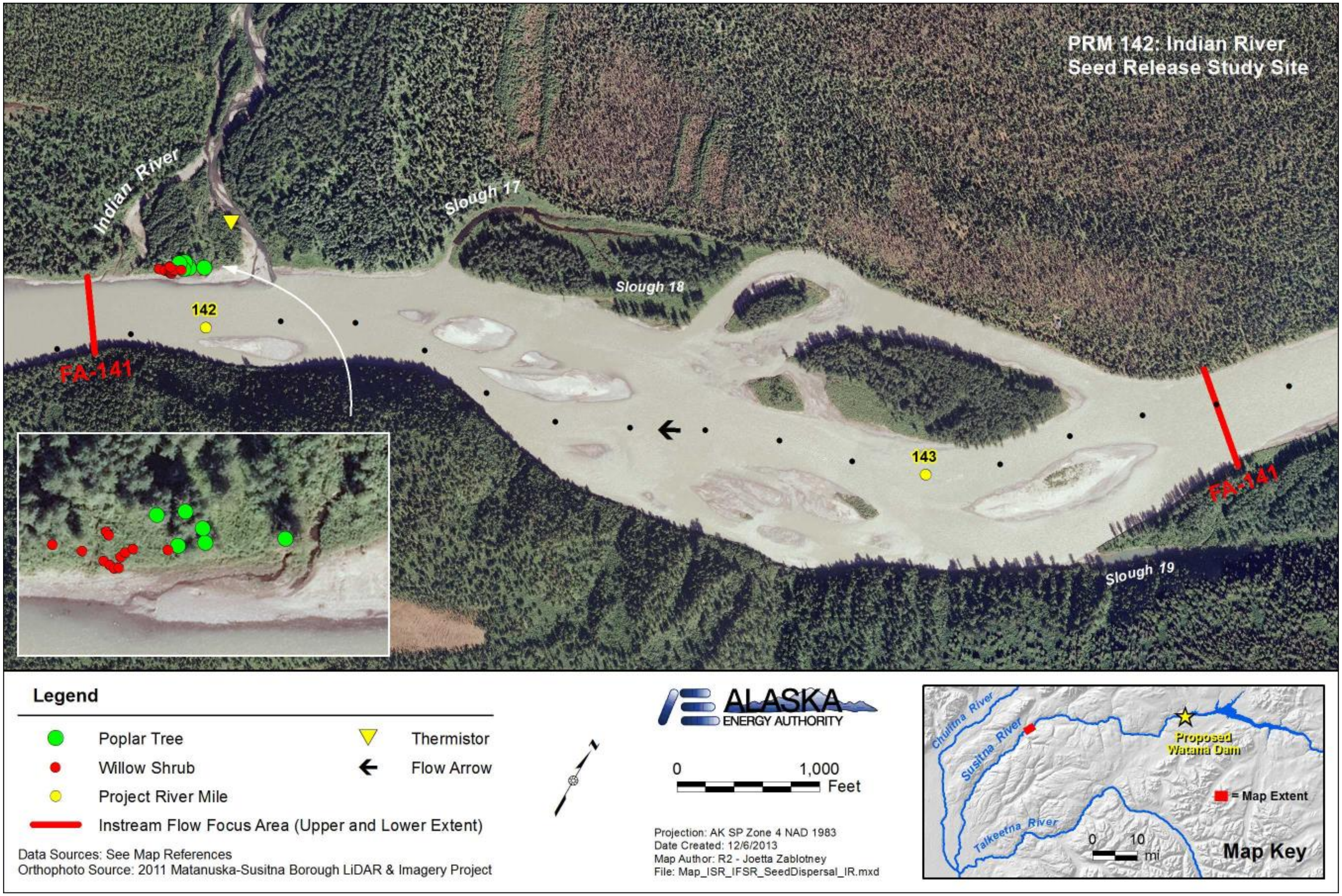


Figure 5.3-5. Seed Dispersal Study Site at PRM 142: Indian River

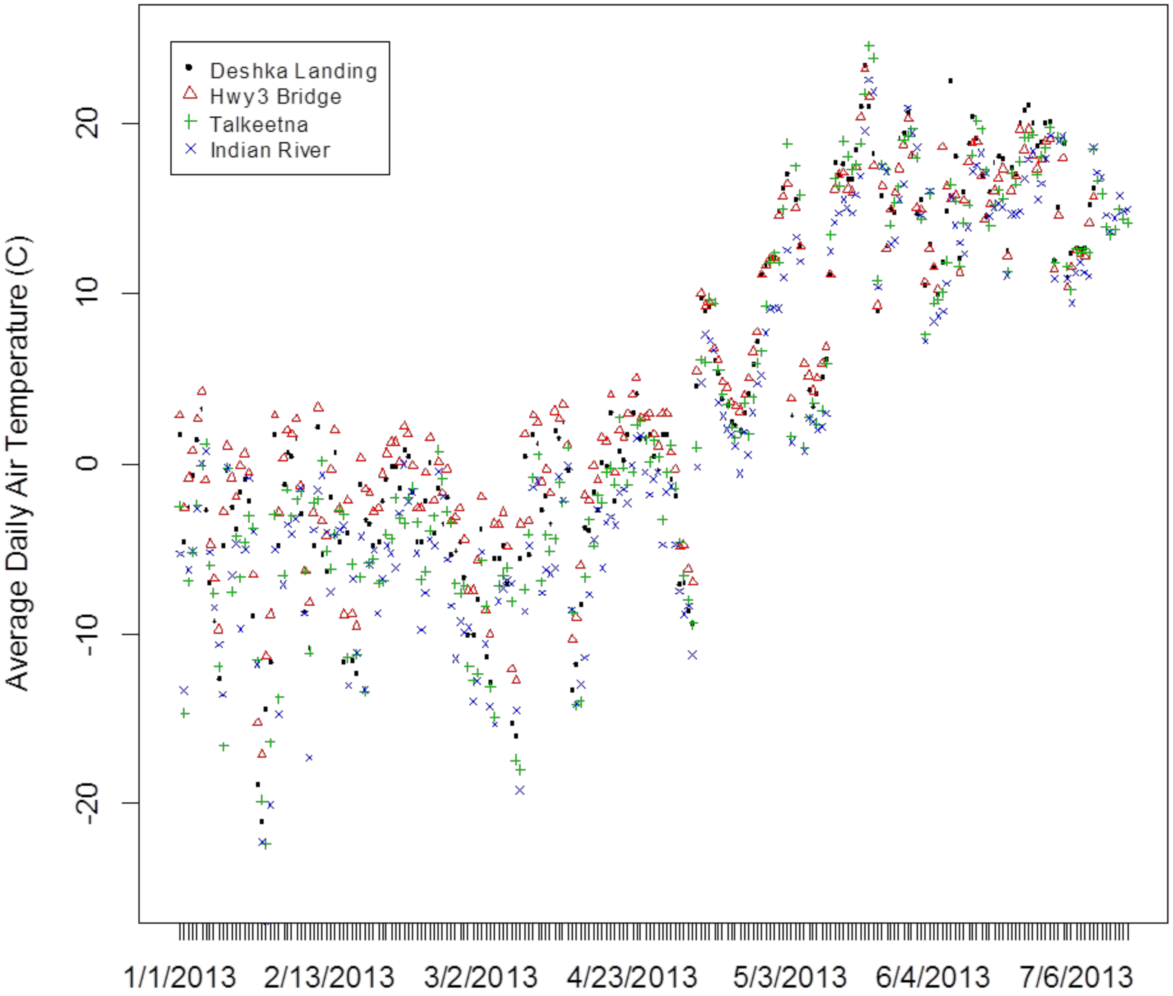


Figure 5.3-6. Daily air temperatures used for modeling at four sites.

PRM 47 (Deshka Landing) and PRM 88 (Parks Highway Bridge) June and July data is from HOBO temperature sensors, with additional temperatures estimated based on correlation with Talkeetna Airport. PRM 102 (Talkeetna) and PRM 142 (Indian River) temperatures from AEA project gauges.

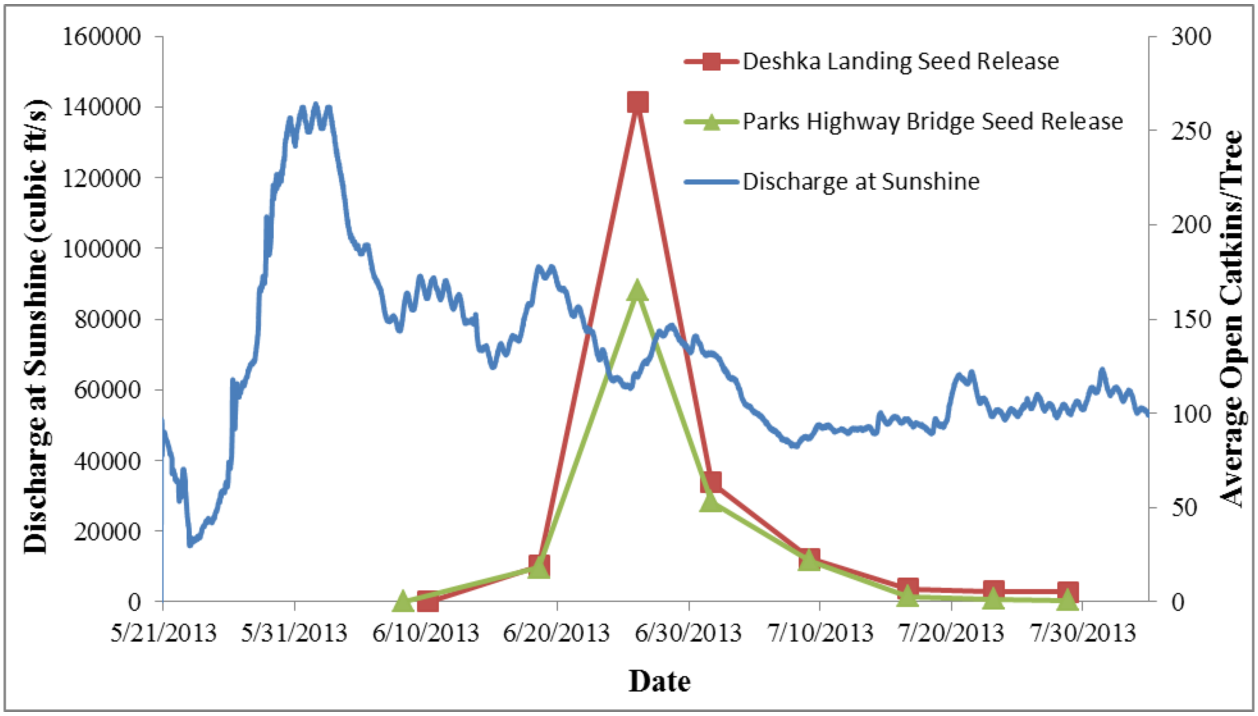


Figure 5.3-7. Peak seed release period in 2013 for *Populus balsamifera* at PRM 47 (Deshka Landing) and PRM 88 (Parks Highway Bridge) with discharge from the USGS Sunshine gauge (PRM 88).

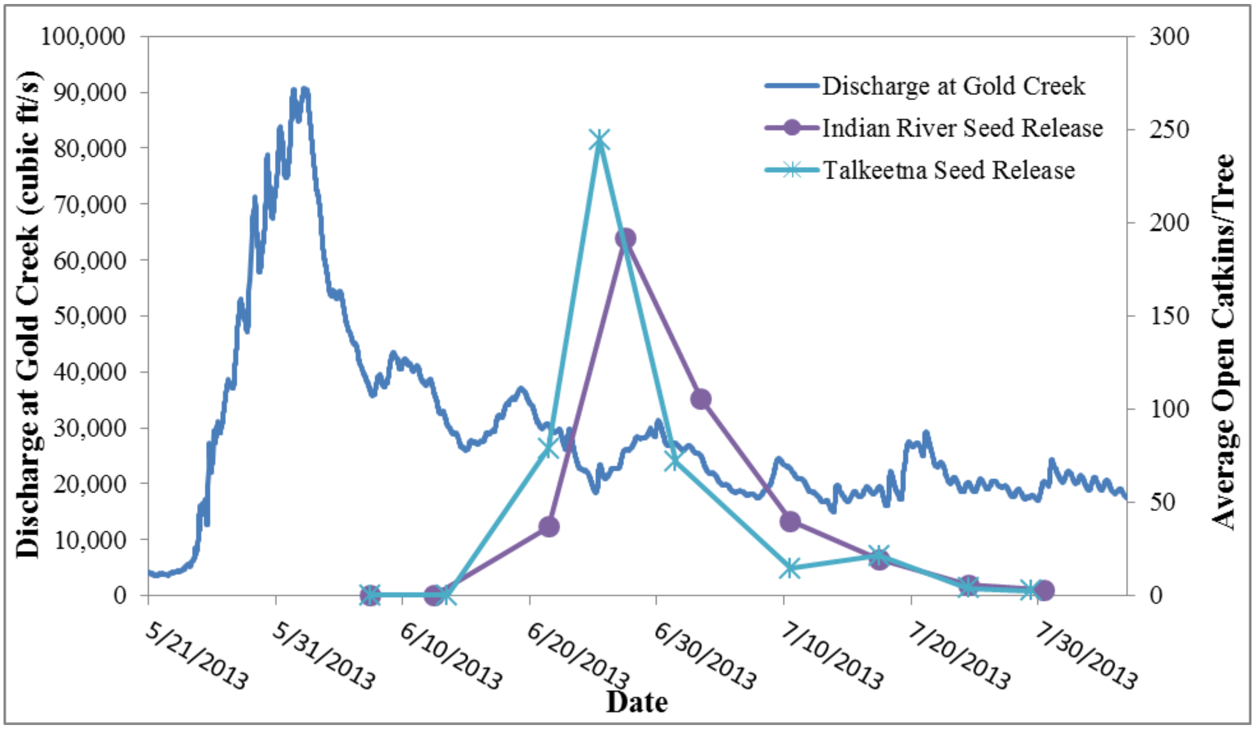


Figure 5.3-8. Peak seed release period in 2013 for *Populus balsamifera* at PRM 102 (Talkeetna) and PRM 142 (Indian River) with discharge from the USGS Gold Creek gauge.

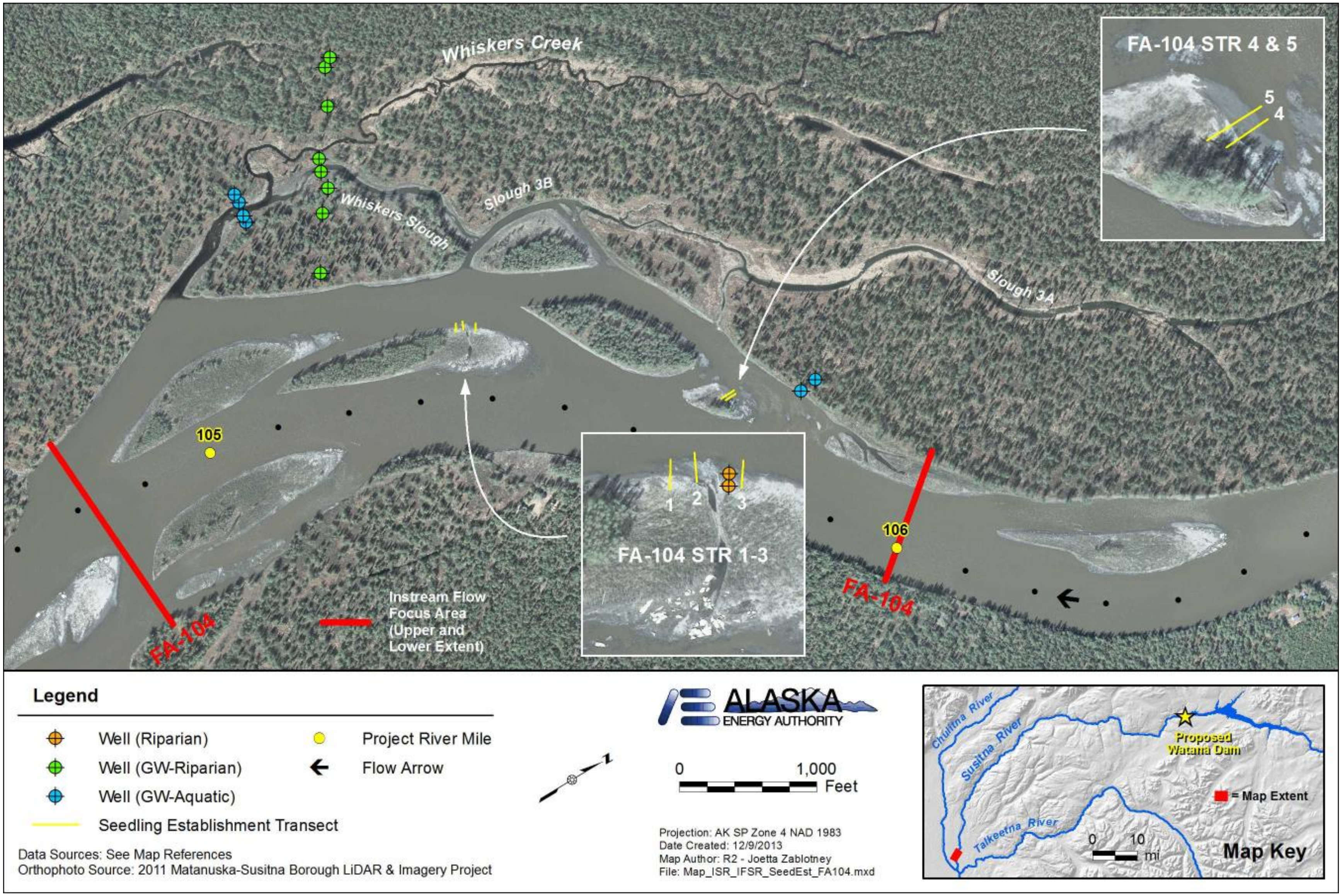


Figure 5.3-9. Seedling Establishment Study Transect Locations at FA104.

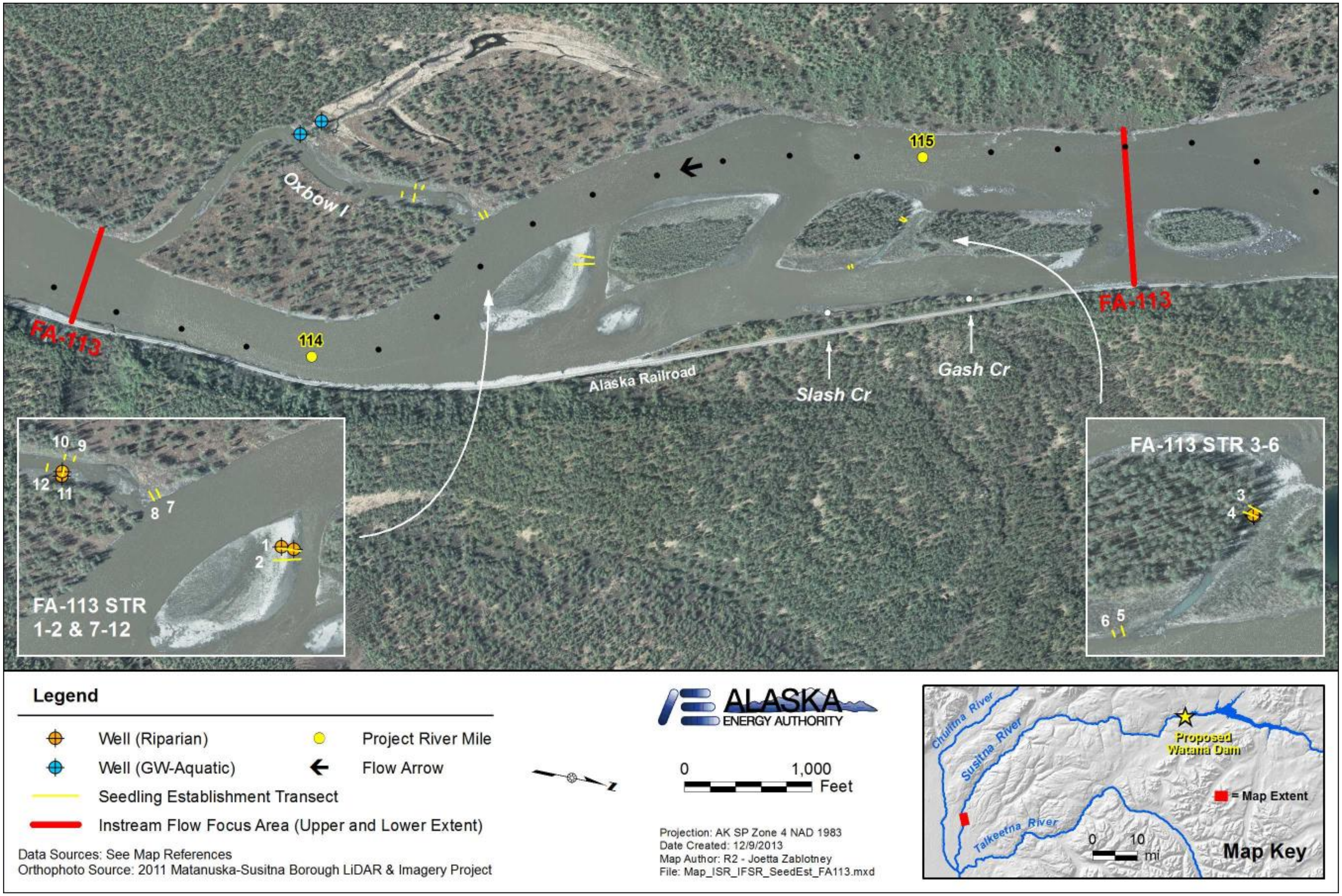


Figure 5.3-10. Seedling Establishment Study Transect Locations at FA113.

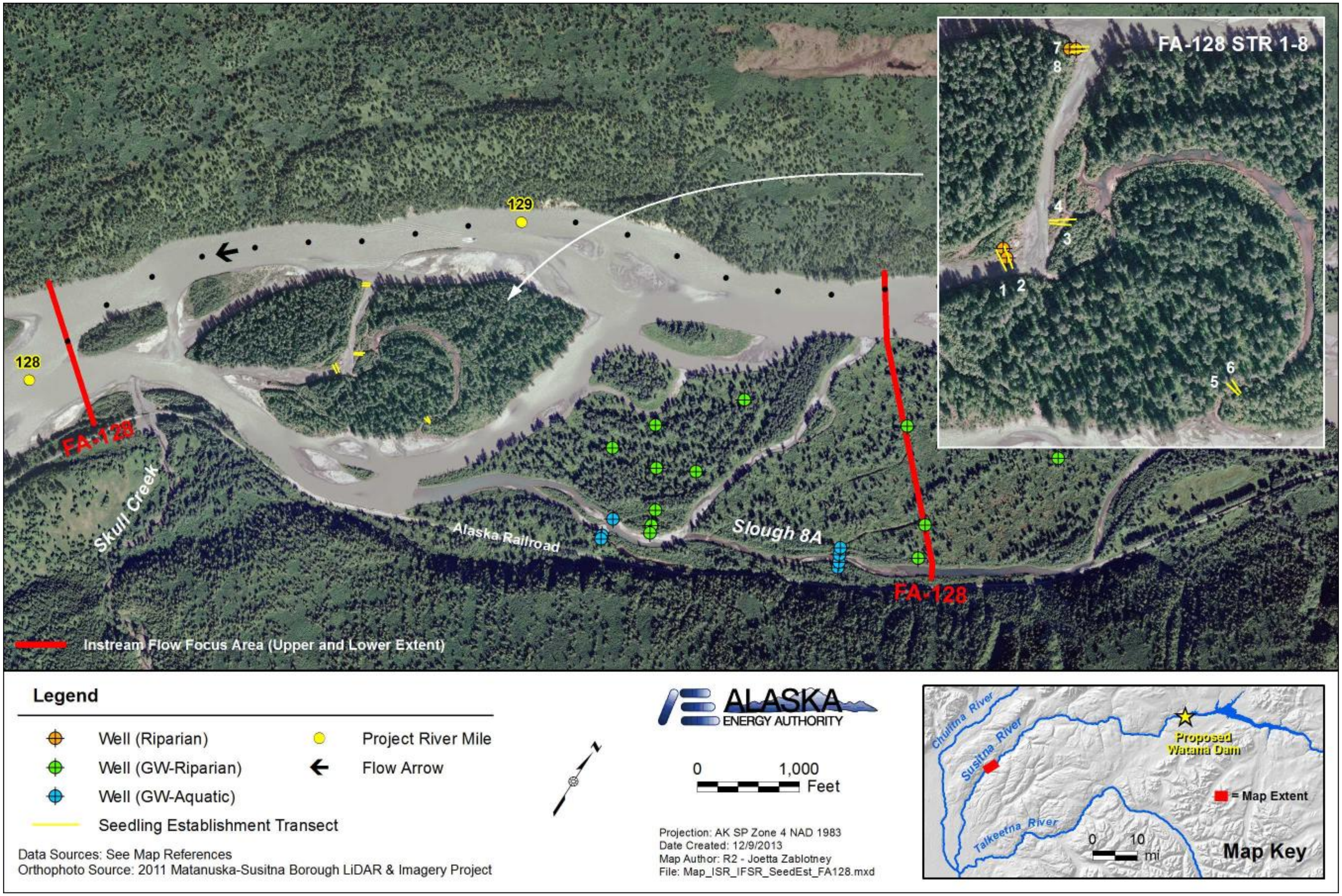


Figure 5.3-11. Seedling Establishment Study Transect Locations at FA128.

Figure 5.3-12. Seedling Establishment Study Transect Locations at FA138.

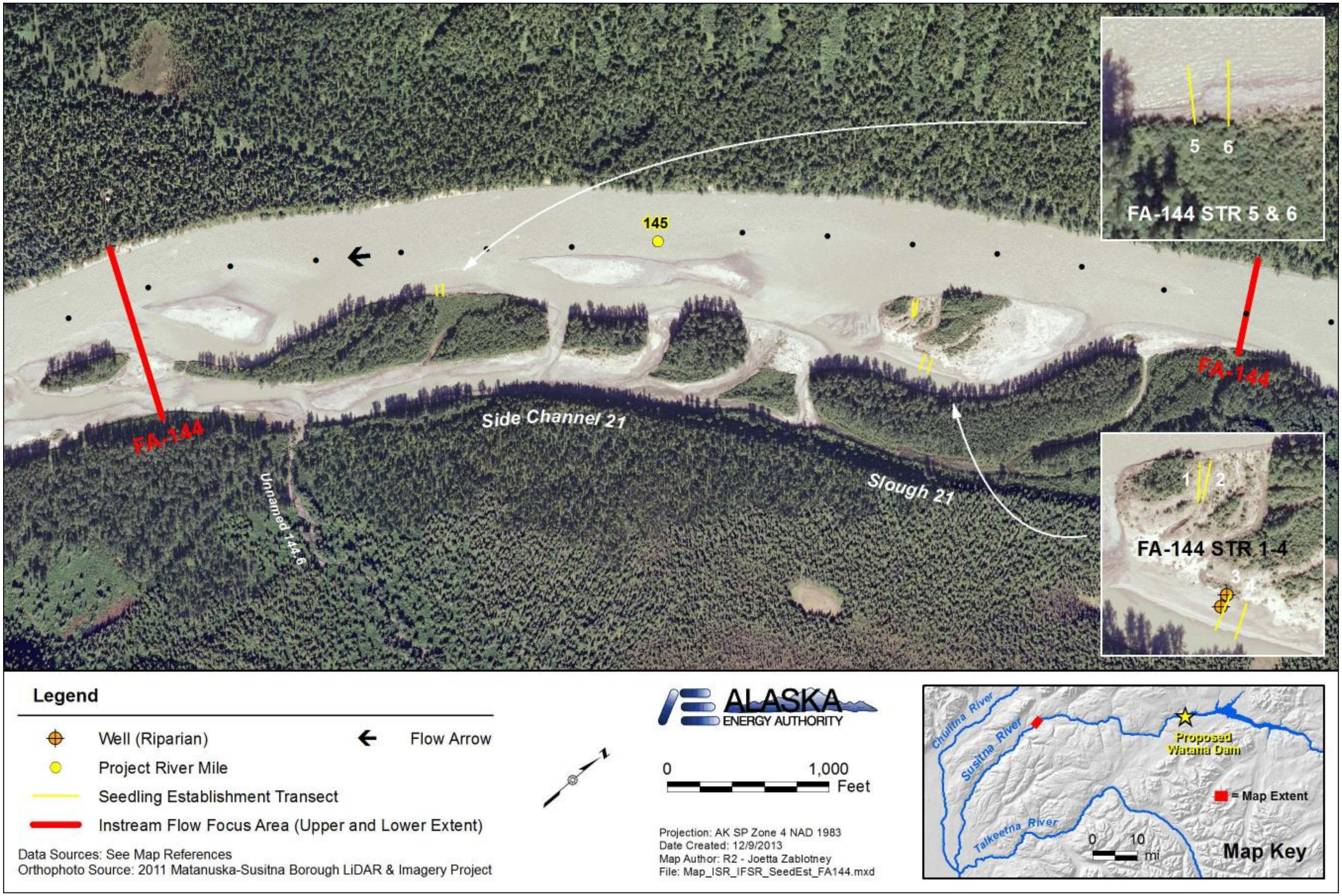


Figure 5.3-13. Seedling Establishment Study Transect Locations at FA144.

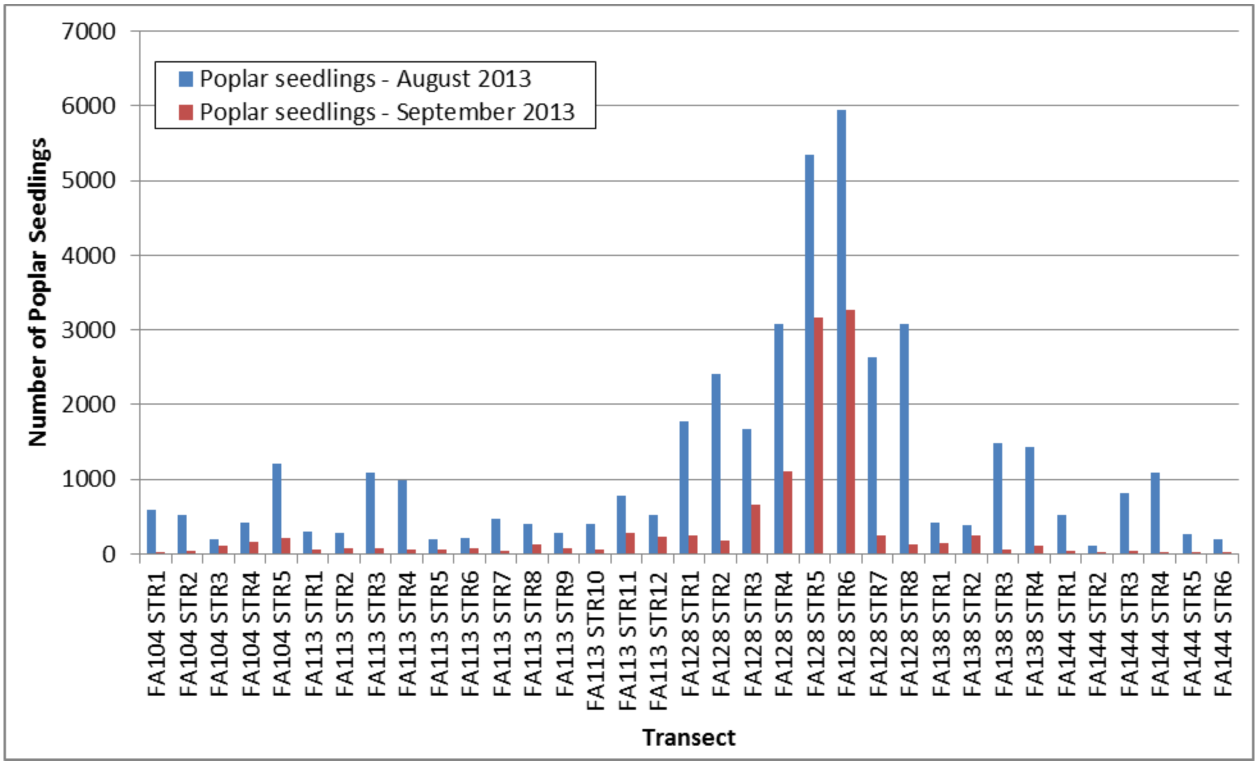


Figure 5.3-14. Year 1 poplar seedling survival by transect between August and September sampling periods.

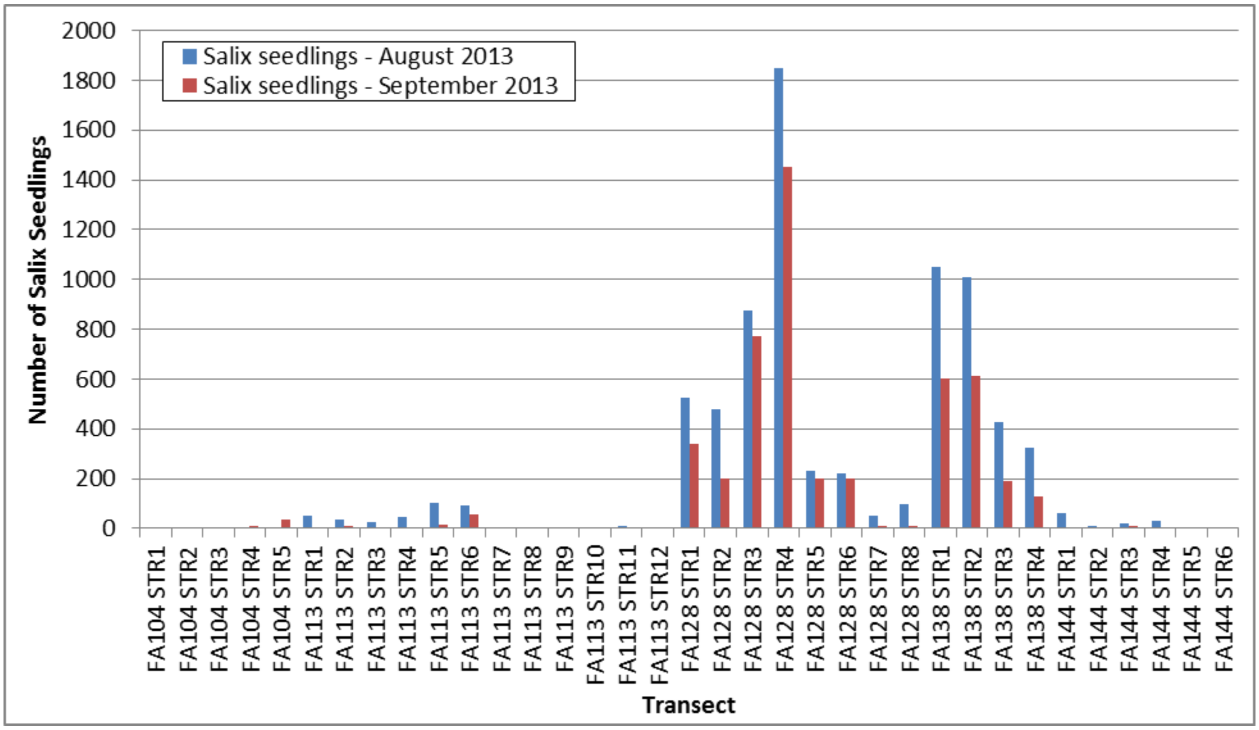


Figure 5.3-15. Year 1 willow seedling survival by transect between August and September sampling periods.

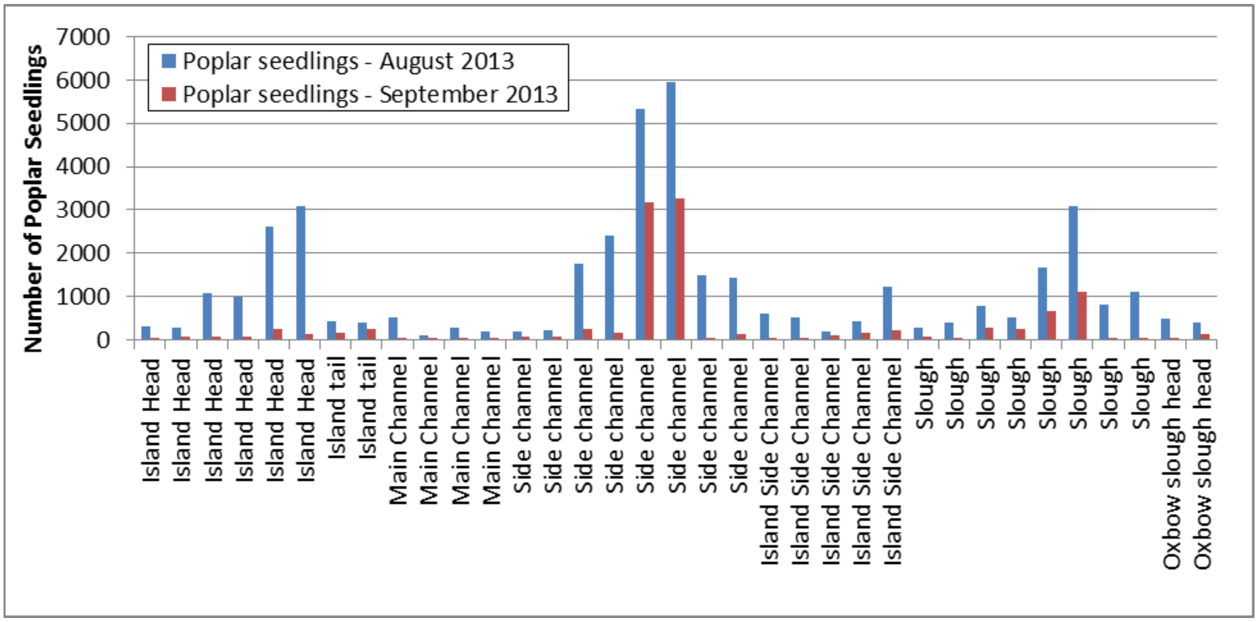


Figure 5.3-16. Year 1 poplar seedling survival plotted by geomorphic position.

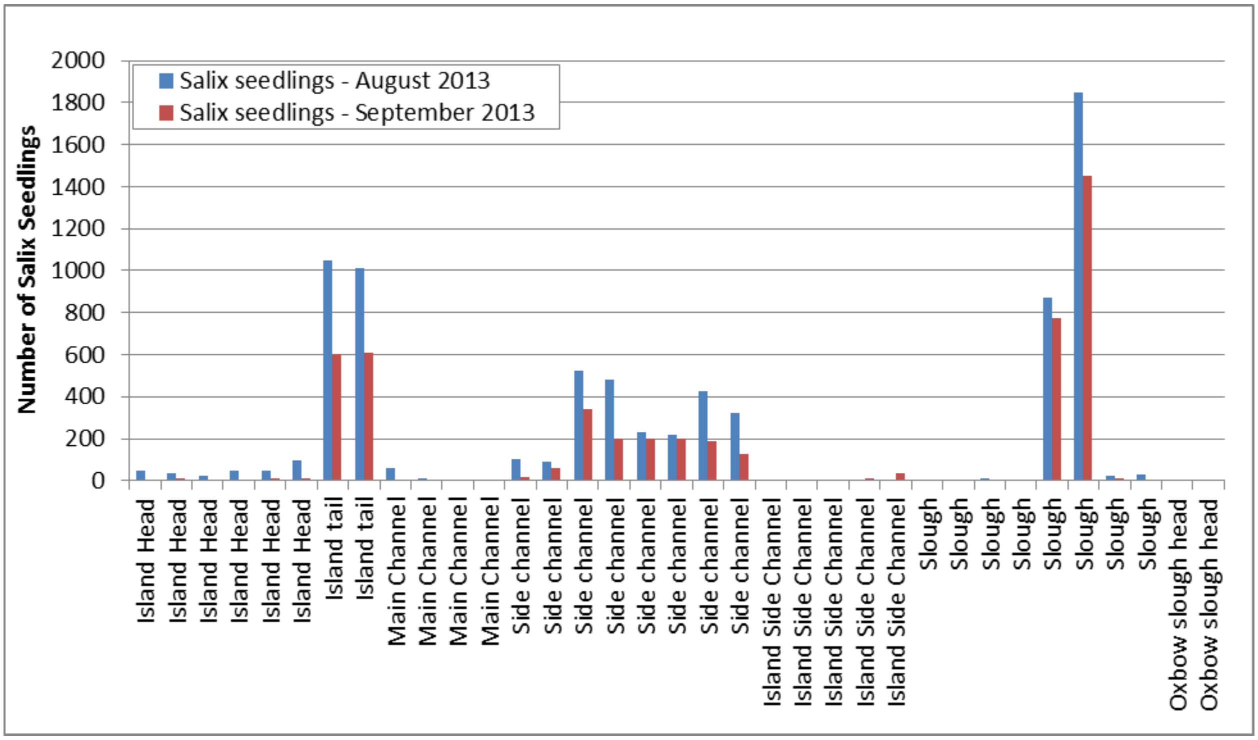


Figure 5.3-17. Year 1 willow seedling survival plotted by geomorphic position.

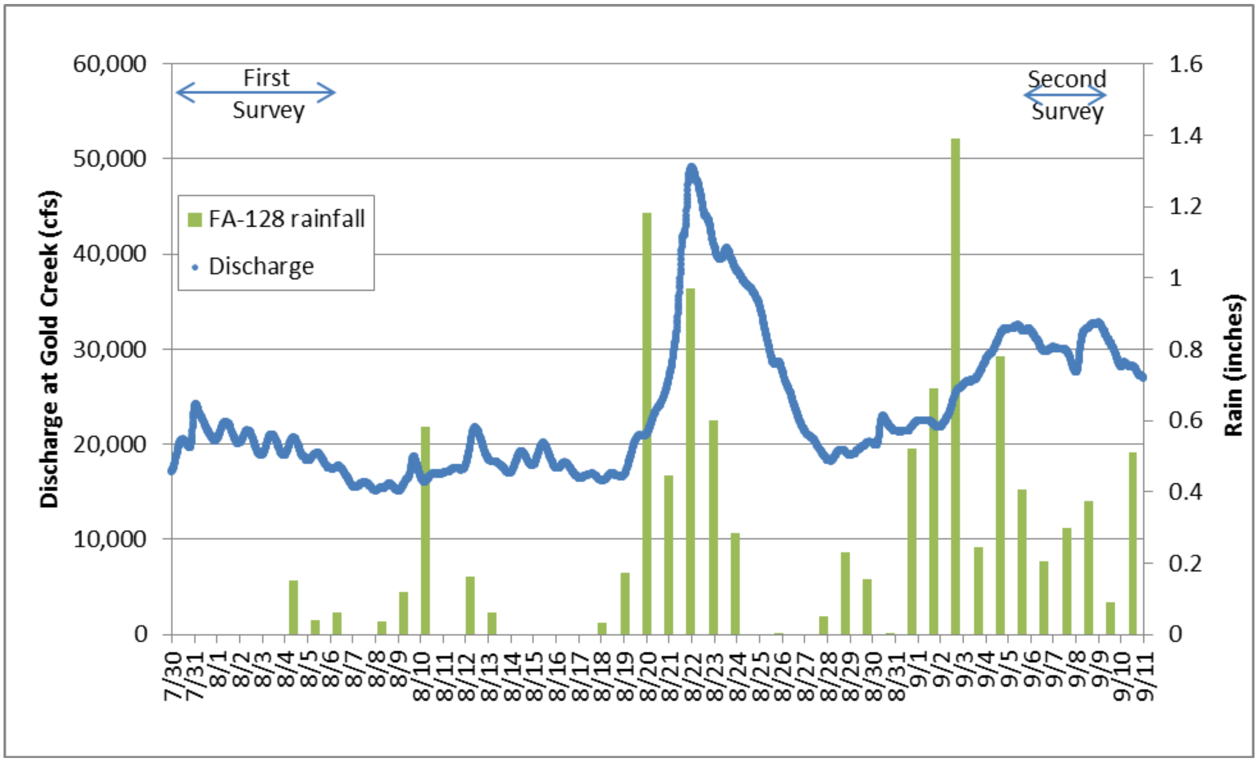


Figure 5.3-18. Discharge at Gold Creek and rainfall observed at FA-104 and FA-128 during the 2013 seedling establishment sampling period.

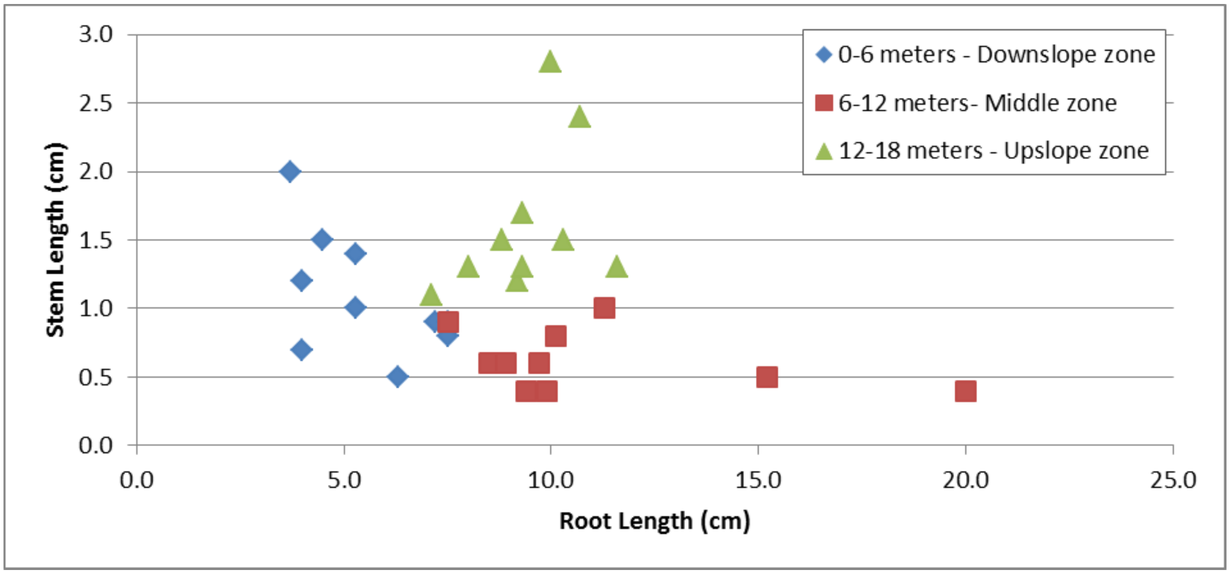
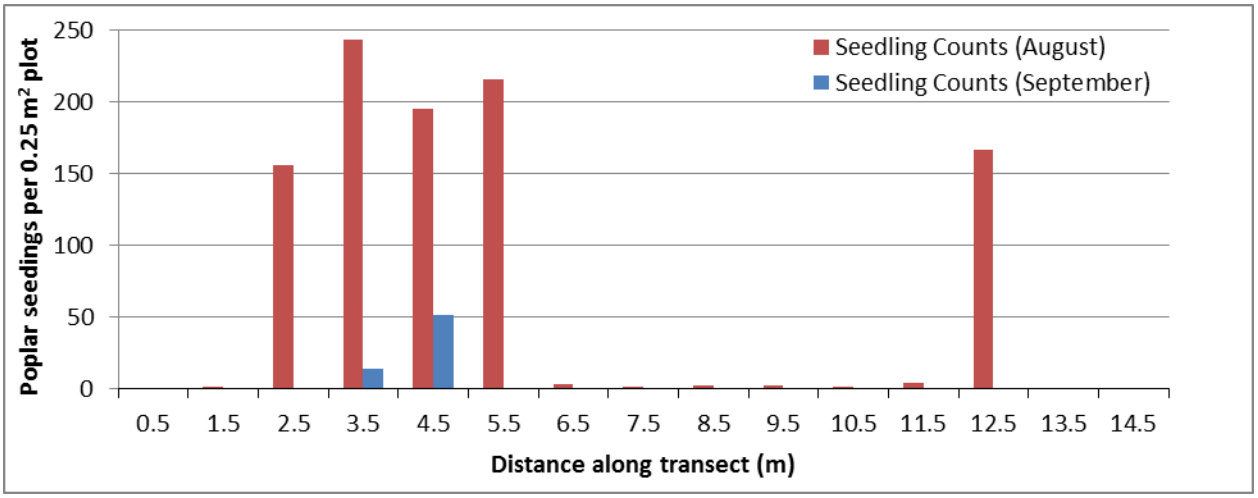


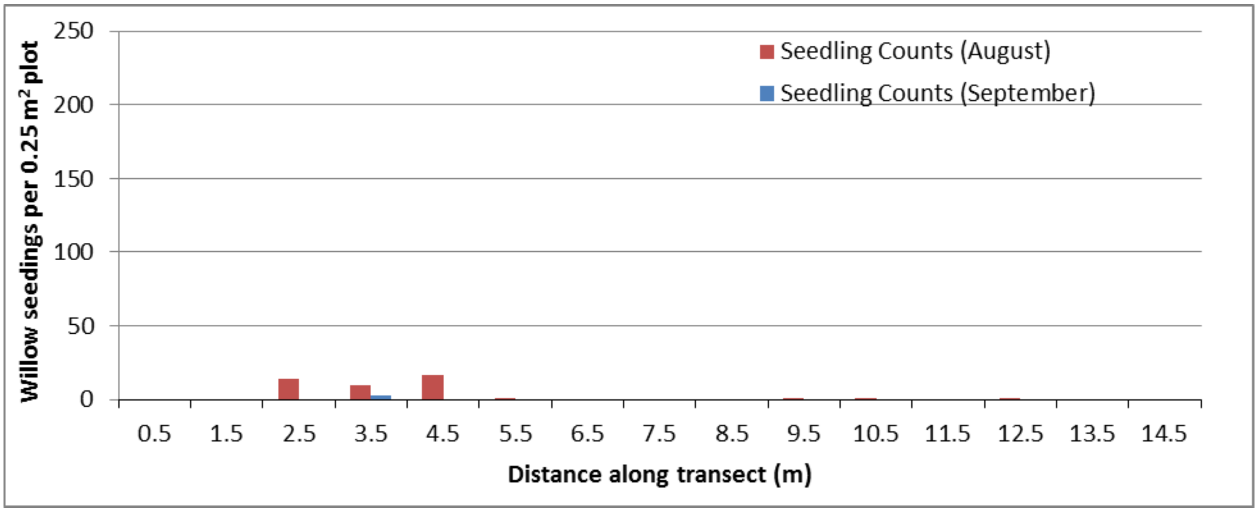
Figure 5.3-19. Stem length versus root length of first year poplar seedlings along Transect FA-104 STR1.

Note: Distances are meters from the end of the transect closest to the main channel.

(a) Poplar Seedling Survival



(b) Willow Seedling Survival



(c) Surface and cobble elevations

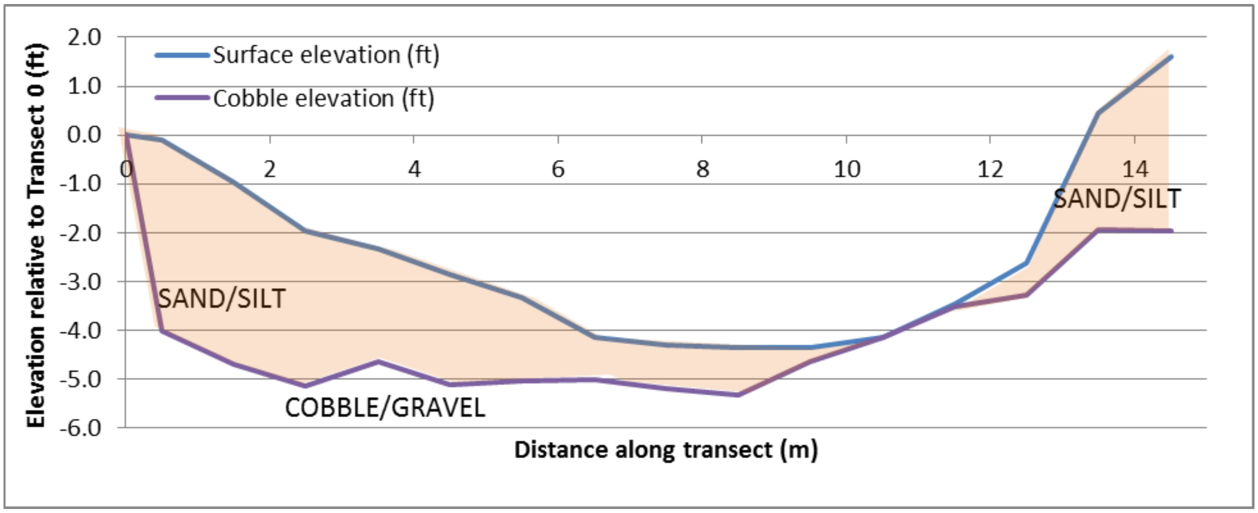
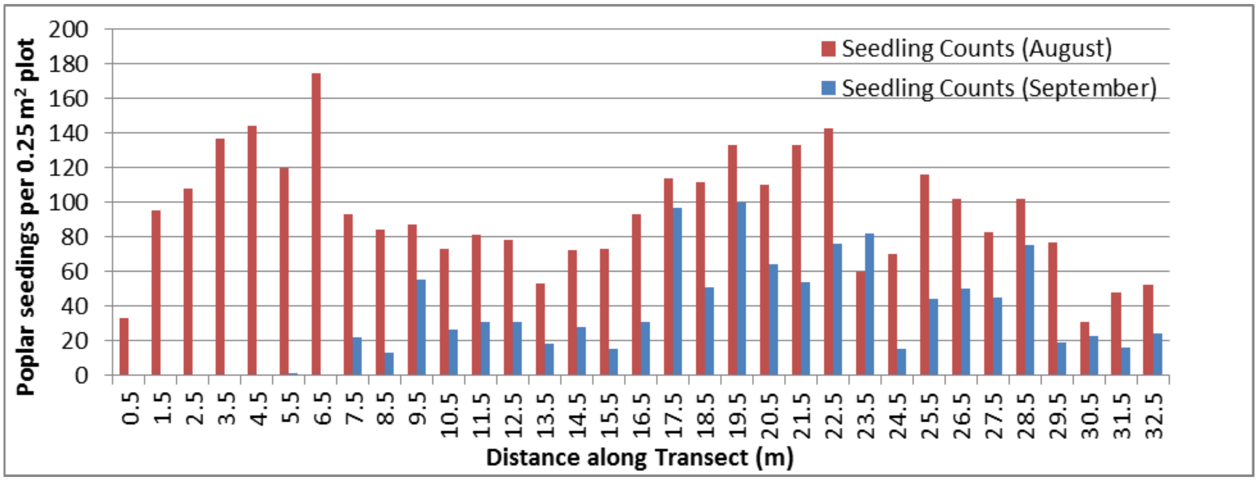
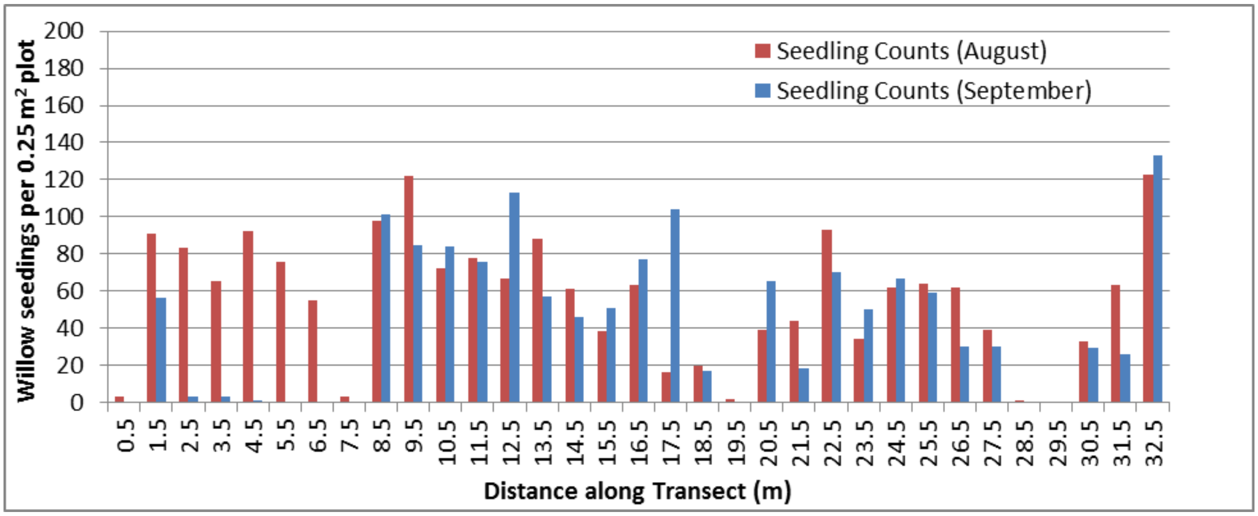


Figure 5.3-20. Seedling survival between August and September sampling efforts and elevation of surface and cobble/gravel armoring (c) at FA113 STR5.

a) Poplar Seedling Survival



b) Willow Seedling Survival



c) Surface and cobble elevations

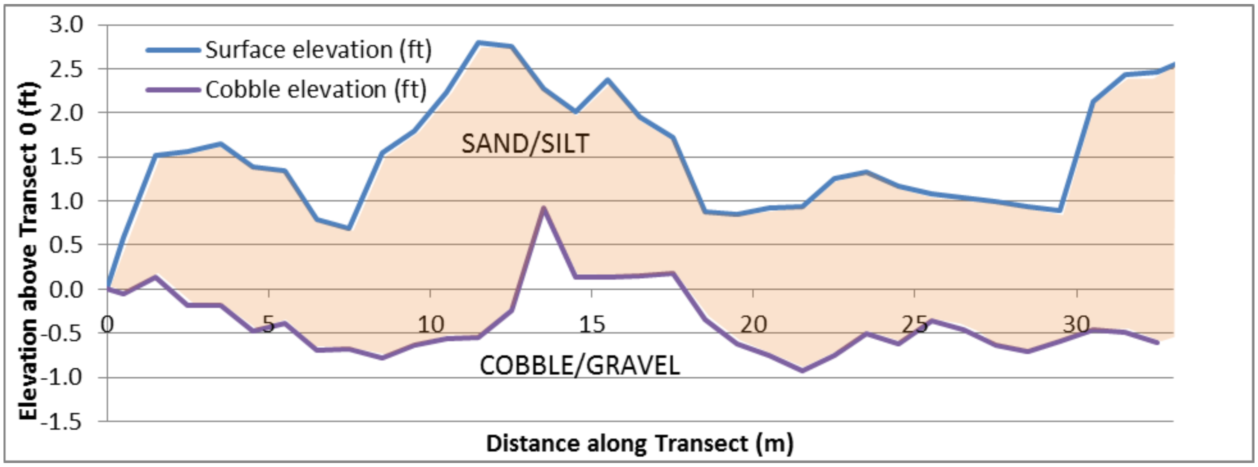
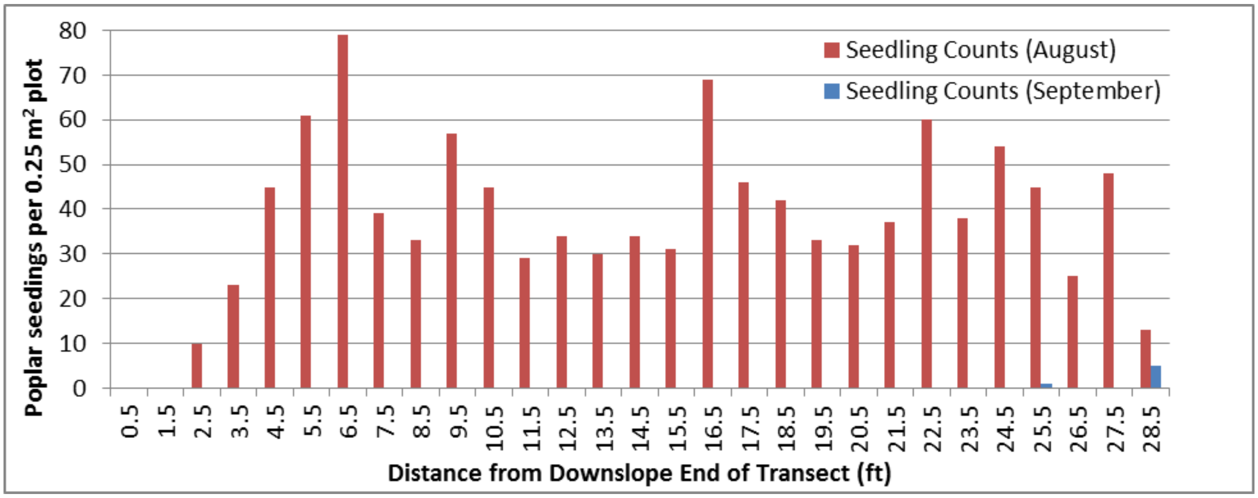
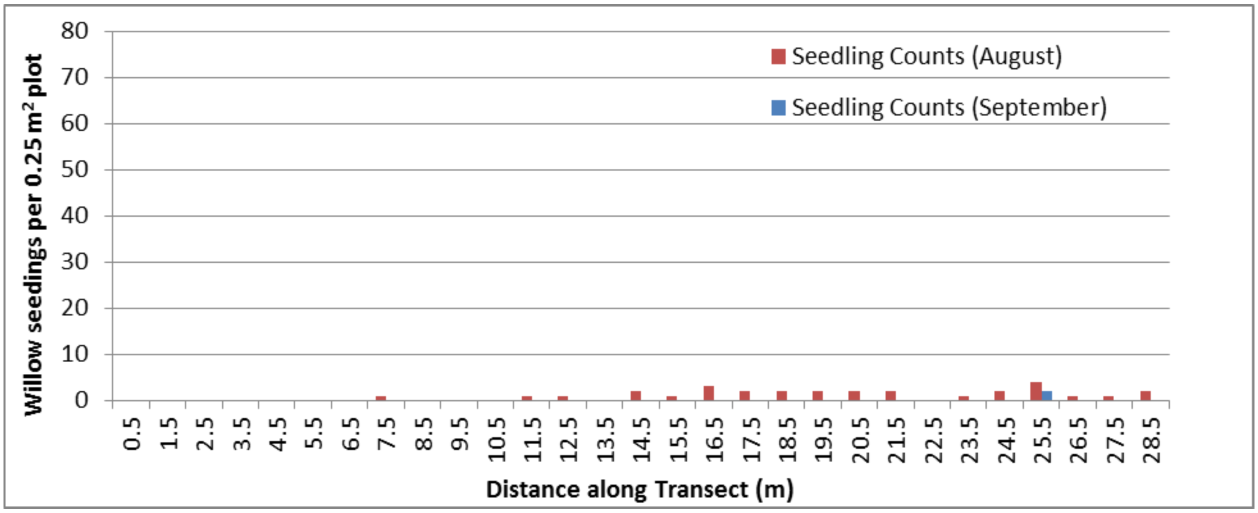


Figure 5.3-21. Seedling survival between August and September sampling efforts and elevation of surface and cobble/gravel armoring (c) at a representative transect FA128 STR4.

a) Poplar seedling survival



b) Willow seedling survival



c) Surface and cobble elevation

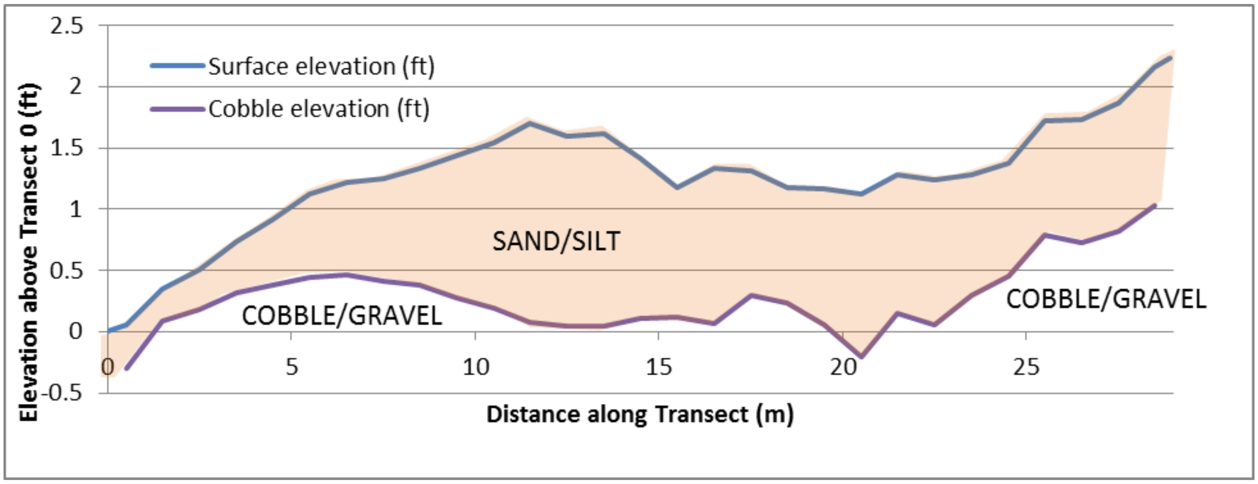


Figure 5.3-22. Seedling survival between August and September sampling efforts and elevation of surface and cobble/gravel armoring (c) at a representative transect FA144 STR4.

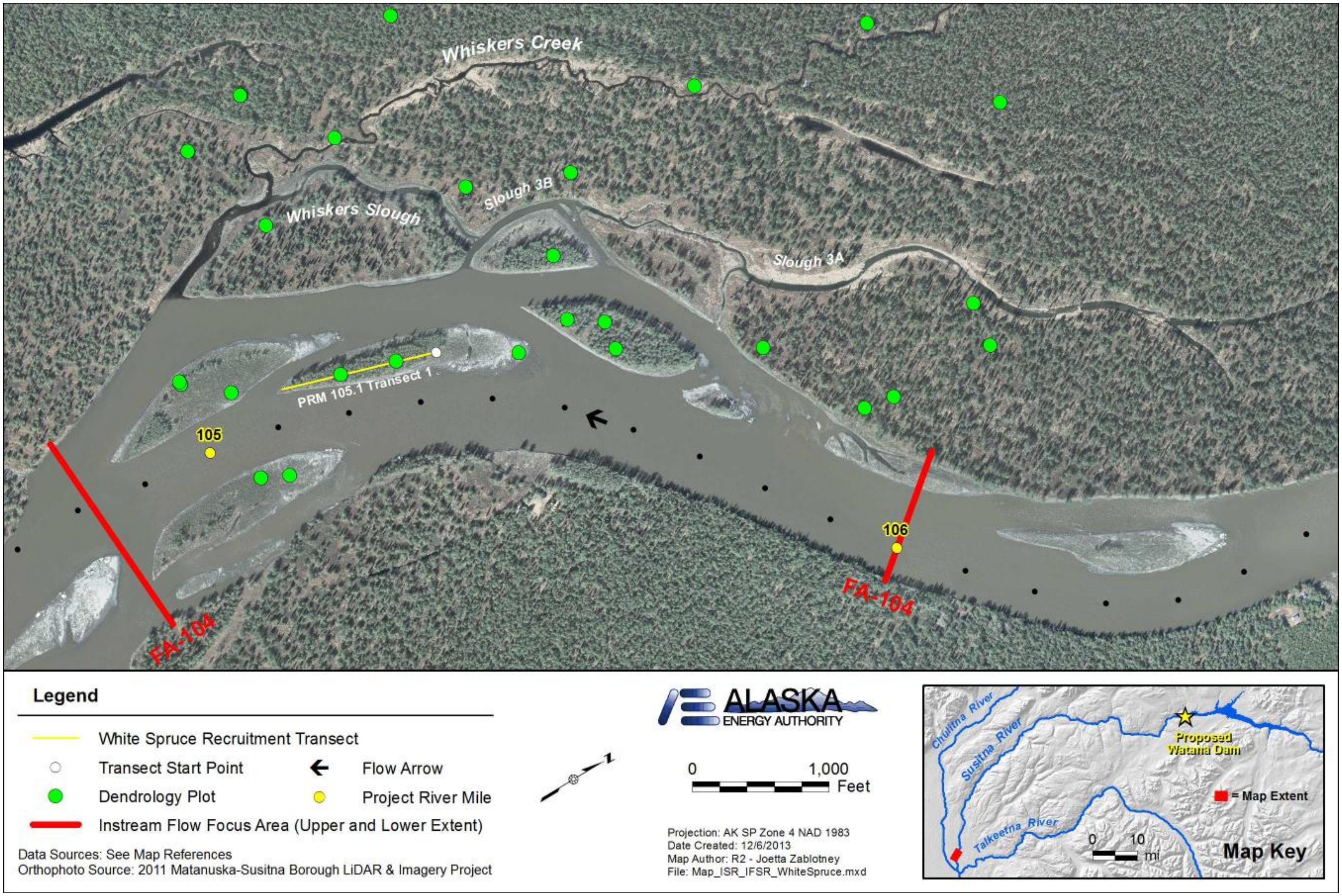


Figure 5.3-23. White spruce establishment transect locations and dendrology plots in FA-104.

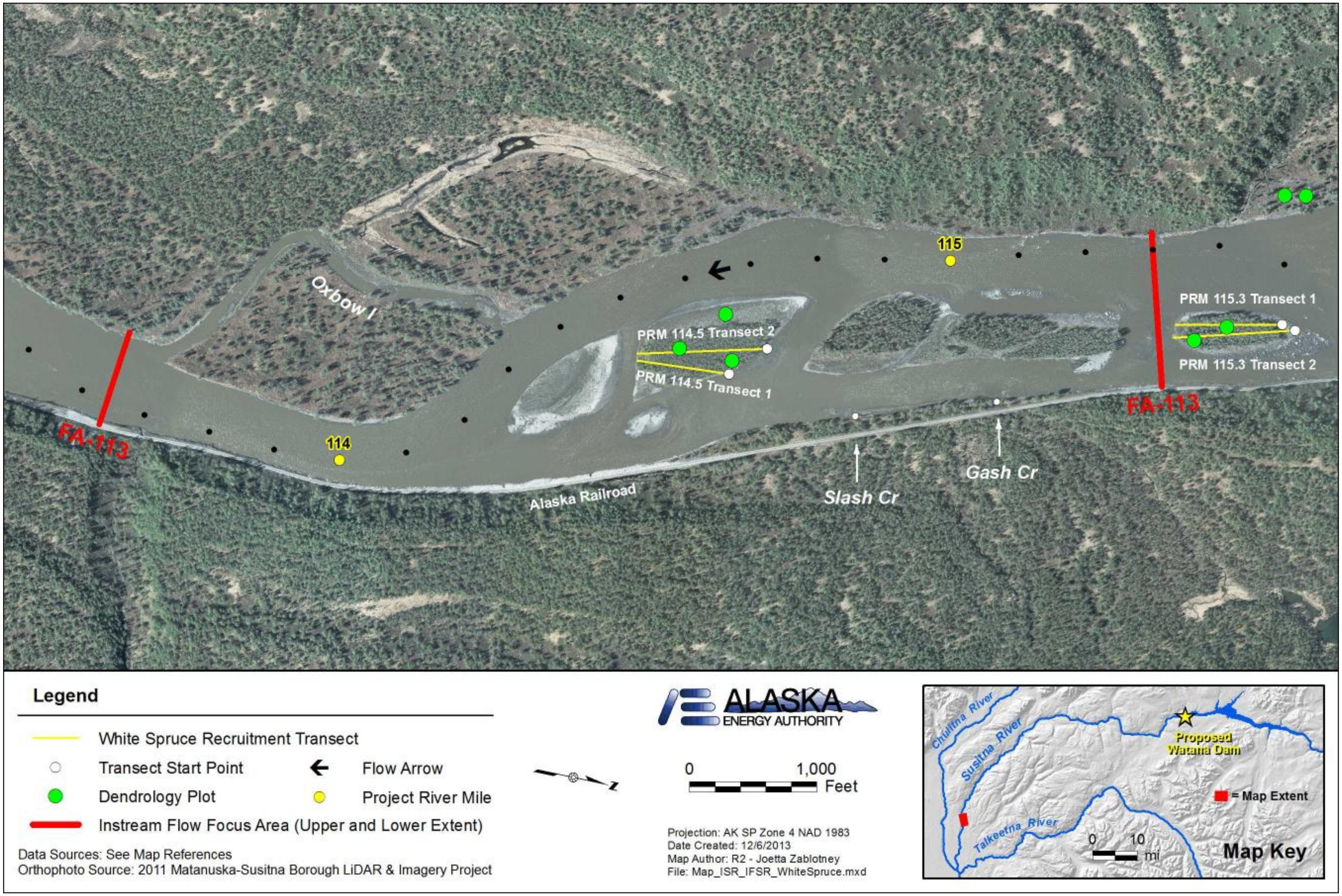


Figure 5.3-24. White spruce establishment transect locations and dendrology plots in FA-113.

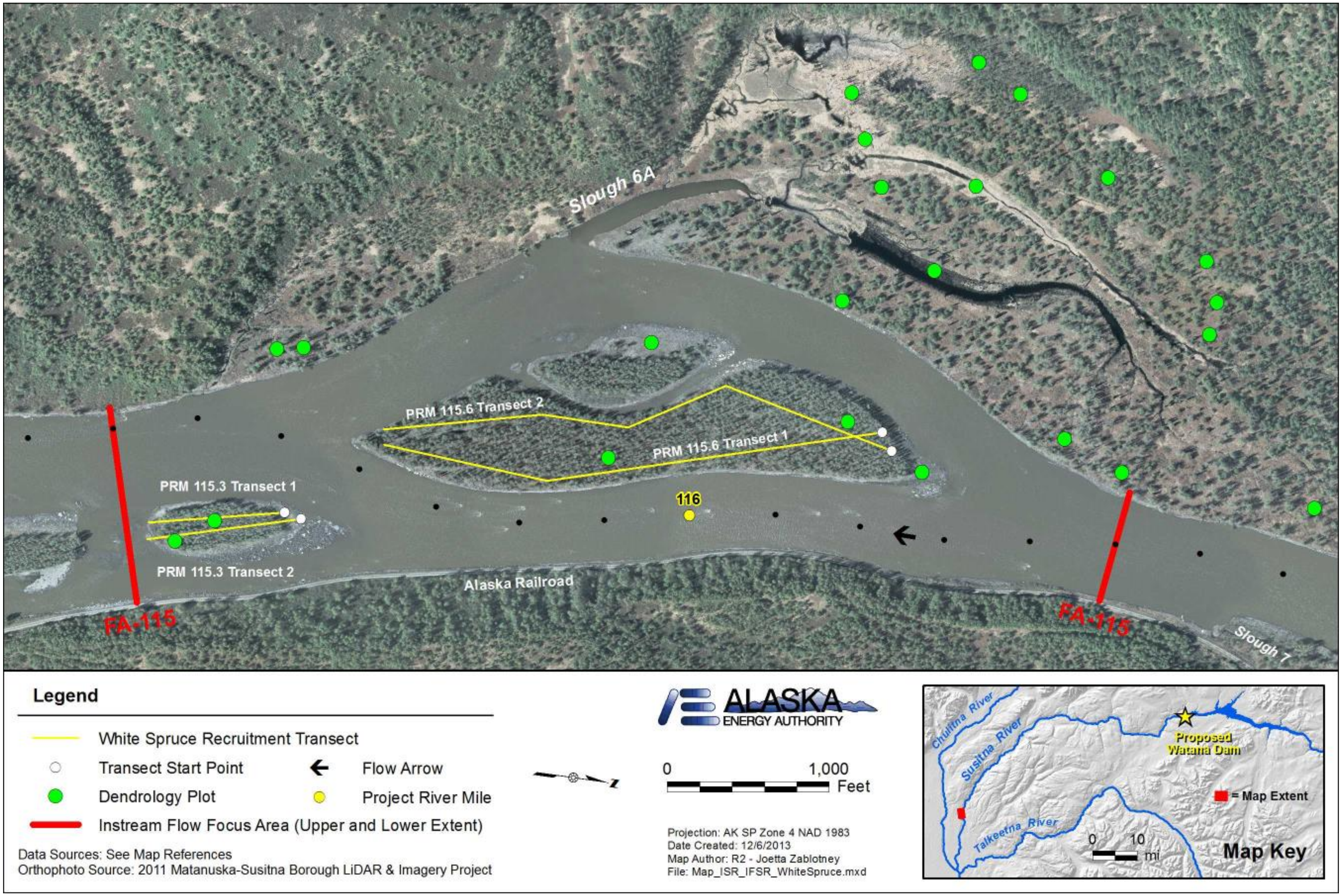


Figure 5.3-25. White spruce establishment transect locations and dendrology plots in FA-115.

Figure 5.3-26. White spruce establishment transect locations and dendrology plots near in FA-128.

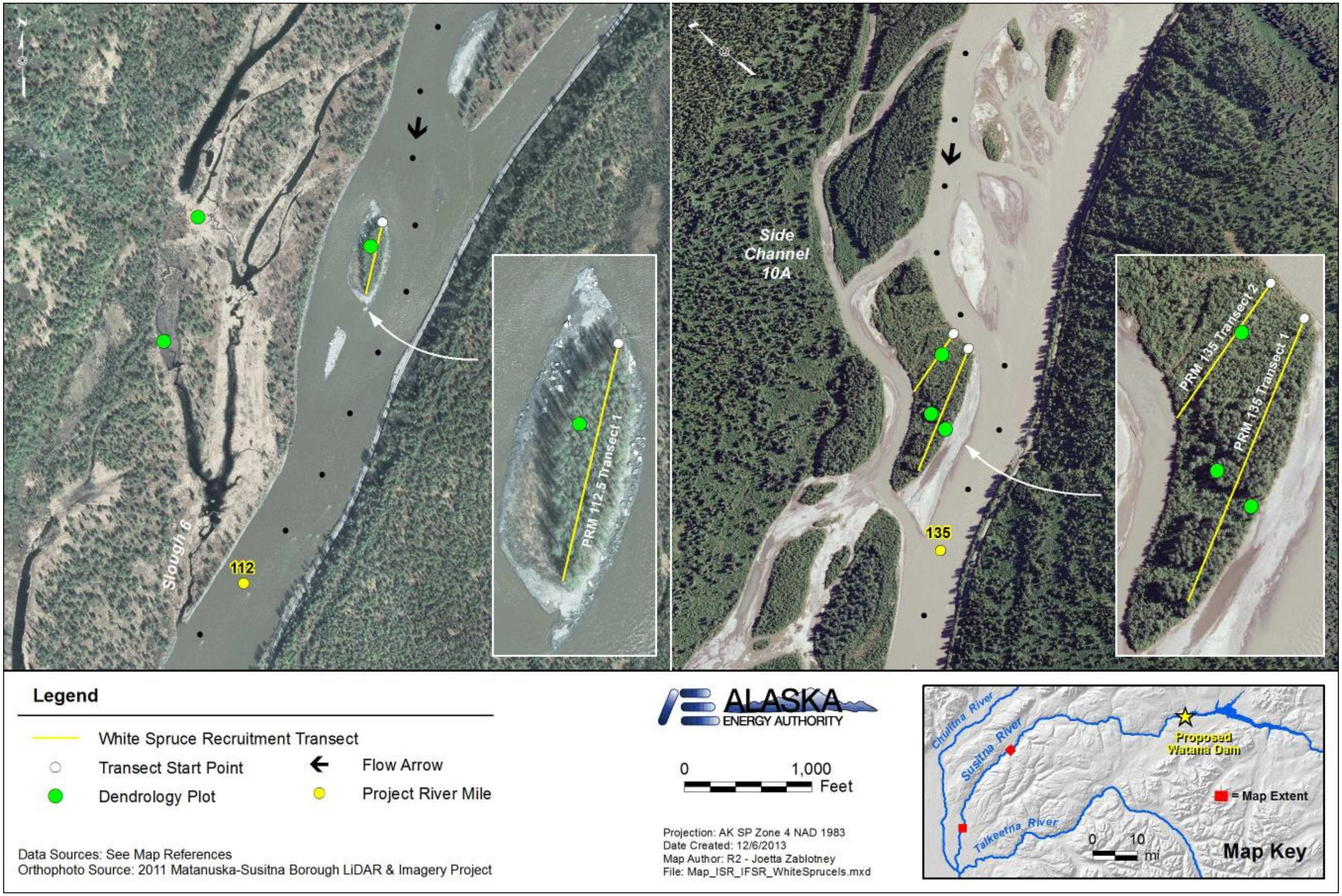


Figure 5.3-27. White spruce establishment transect locations and dendrology plots near PRM 112 and 135.

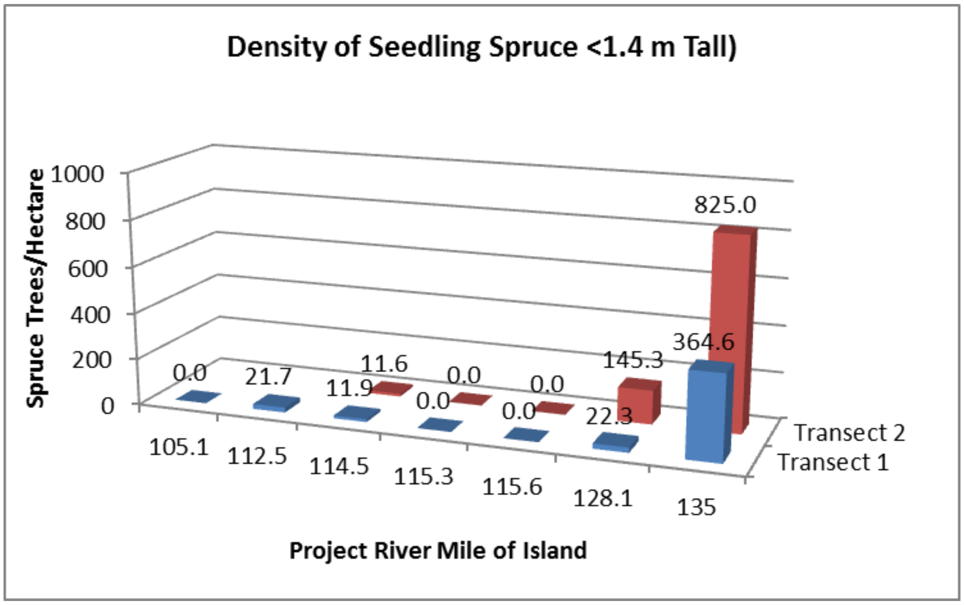


Figure 5.3-28. Total number of seedling spruce trees per hectare along each island transect.

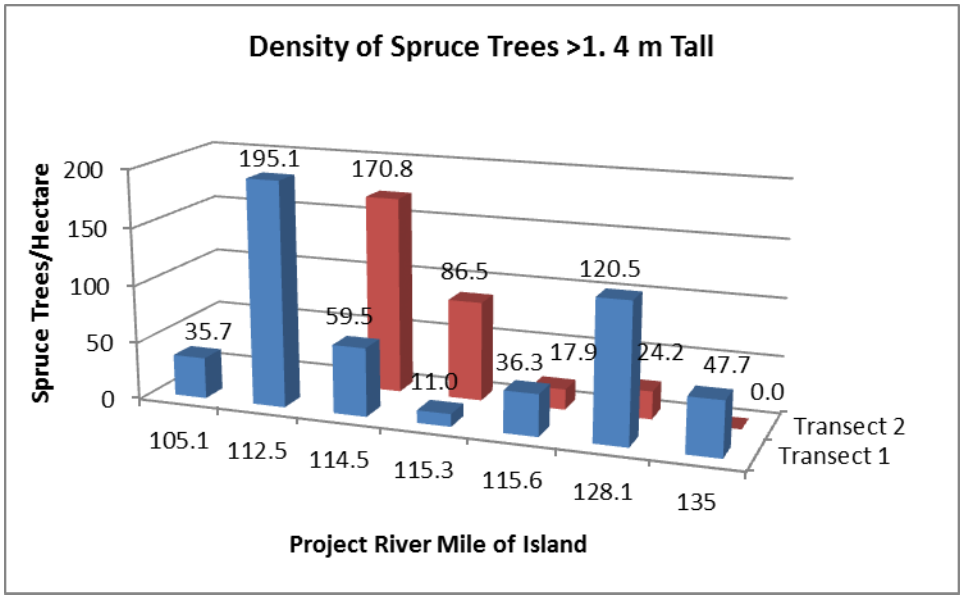


Figure 5.3-29. Total number of spruce trees per hectare along each island transect.

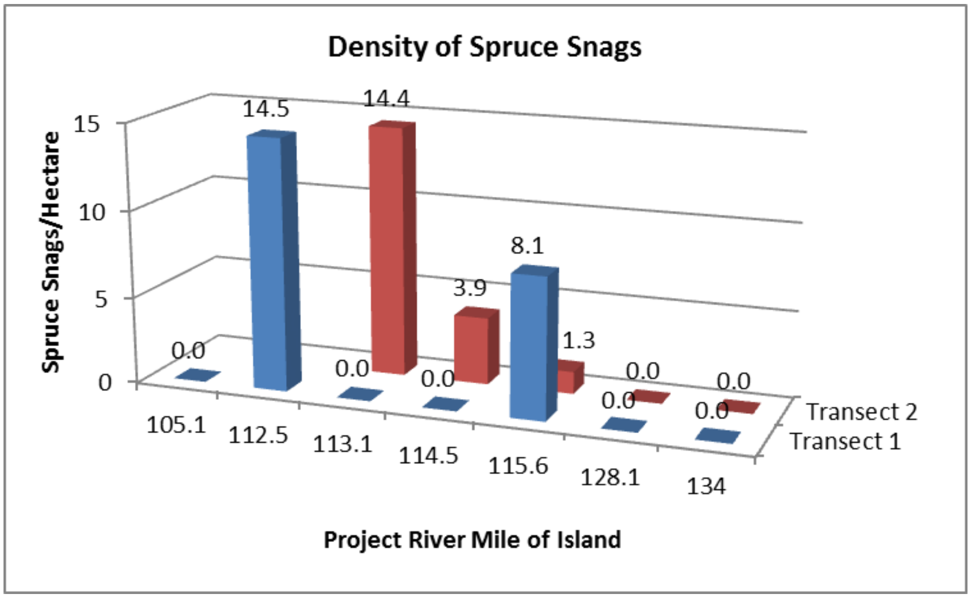


Figure 5.3-30. Total number of snag spruce trees per hectare along each island transect.

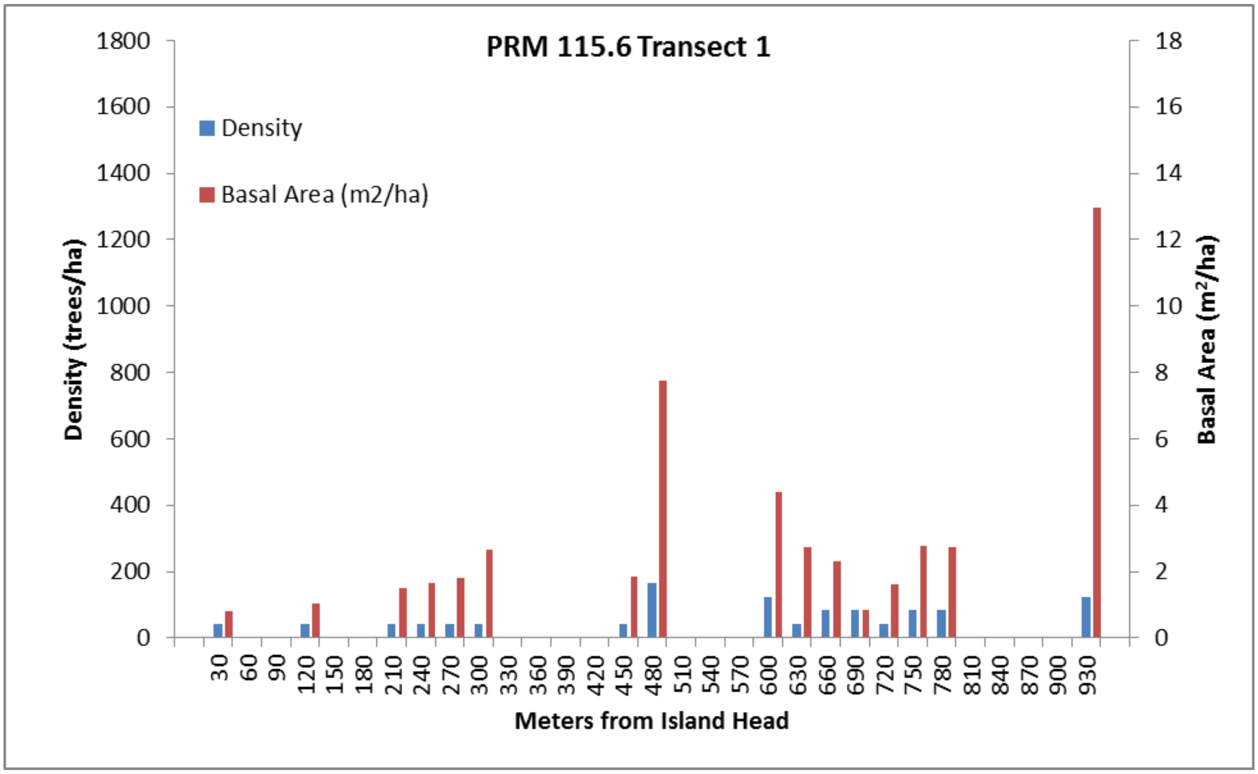


Figure 5.3-31. Spruce density and basal area by 30 meter quadrat increments observed along an eight-meter-wide belt transect (Transect 1) on mid-channel island at PRM 115.6.

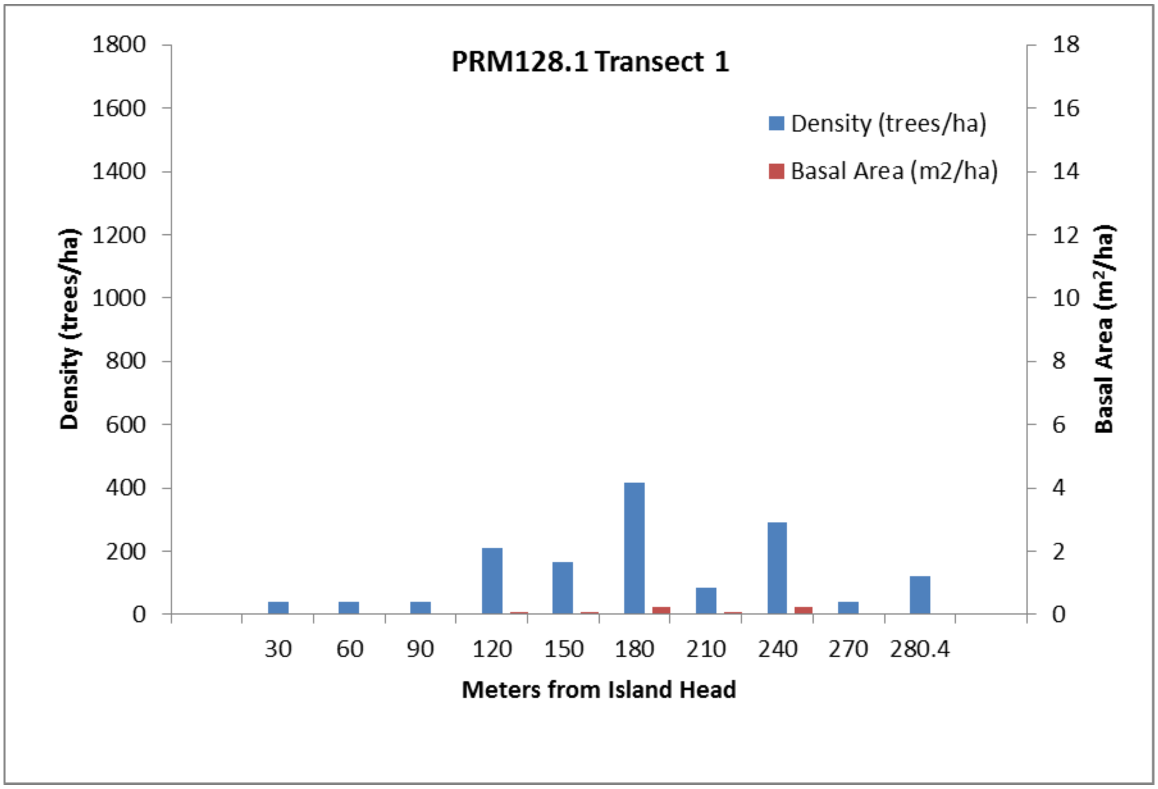


Figure 5.3-32. Spruce density and basal area by 30 meter quadrat increments observed along an eight-meter-wide belt transect (Transect 1) on mid-channel island at PRM 128.1.

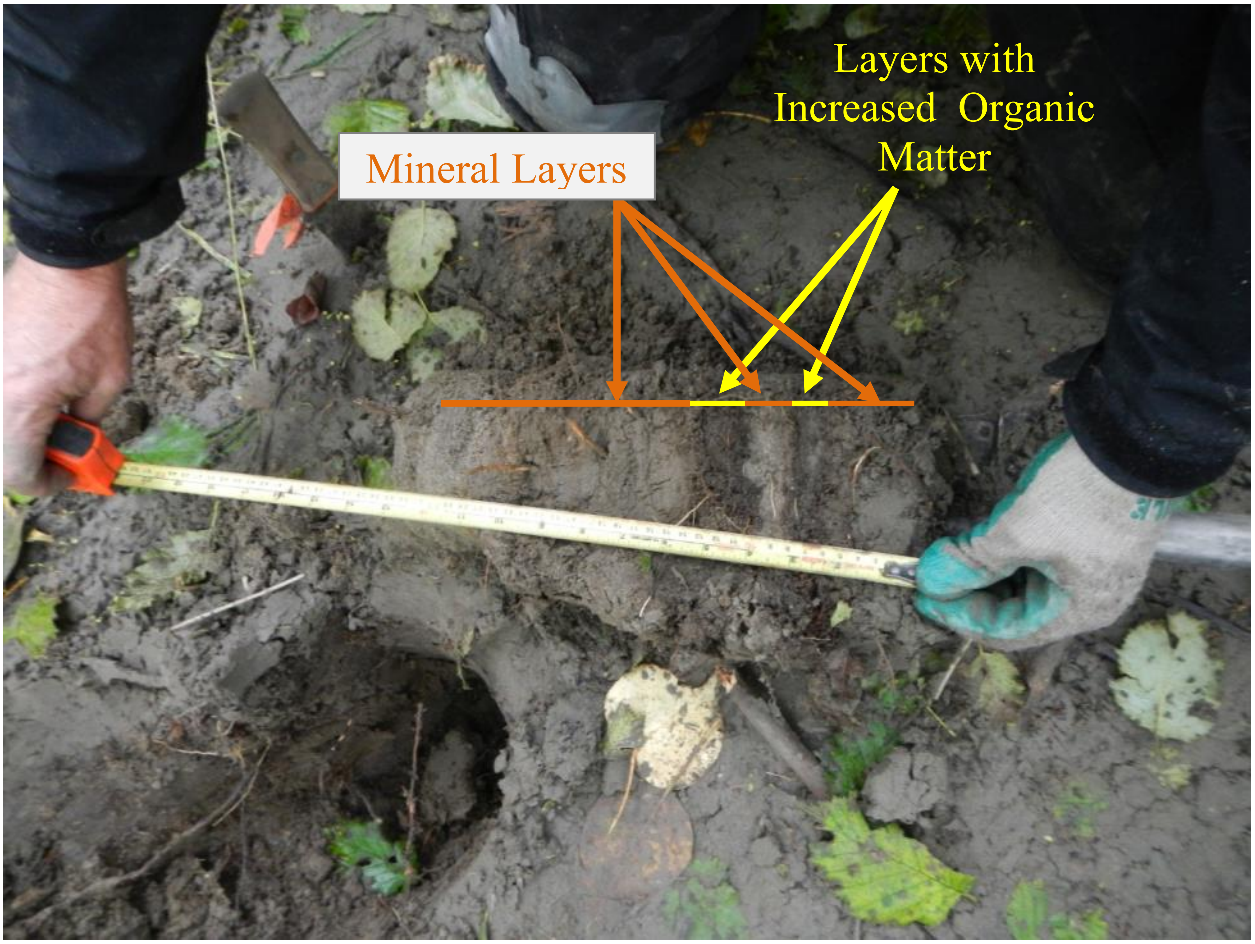


Figure 5.3-33. Example of soil core on island PRM 128.1 showing layers with high organic matter content overlain by mineral soil.

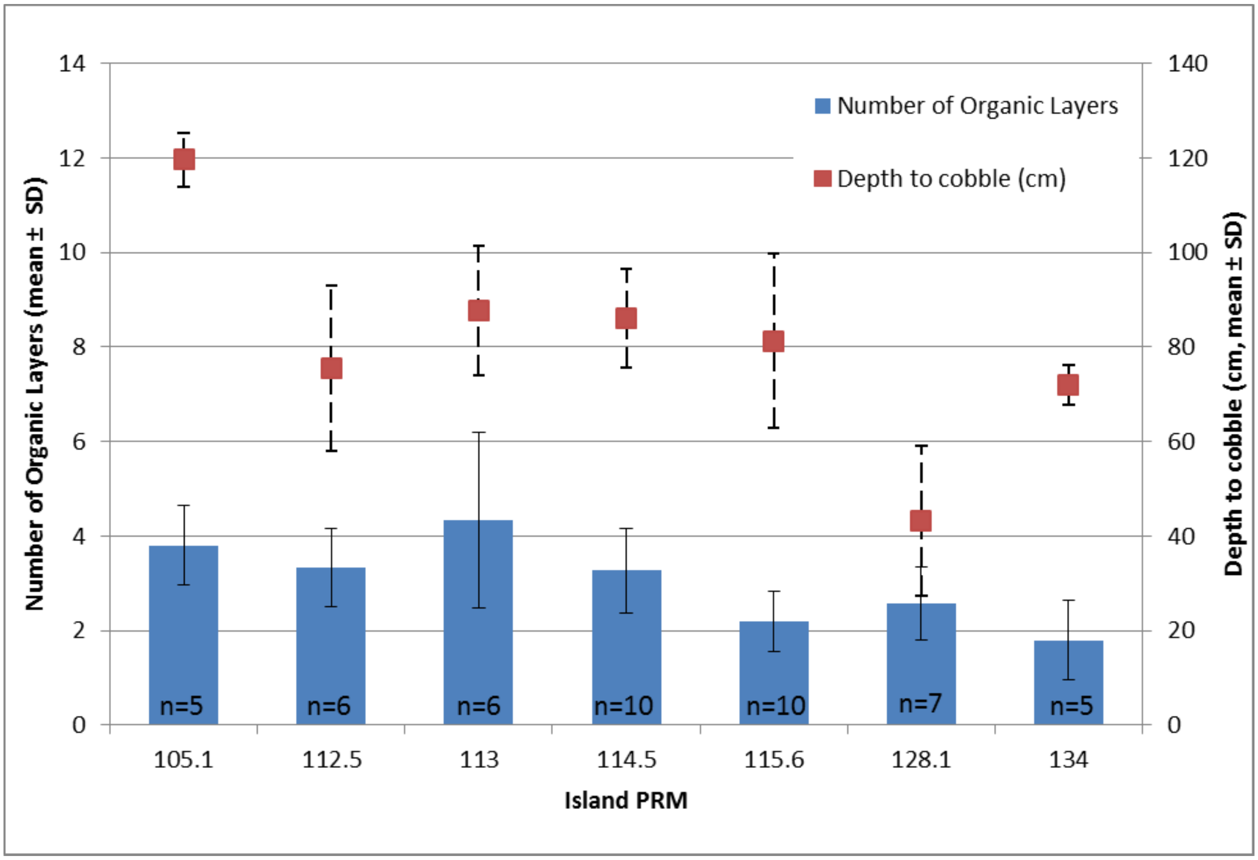


Figure 5.3-34. Mean number of organic layers in upper 30 cm of soil profile and depth to cobble at randomly selected locations across each island in the spruce seedling establishment study.

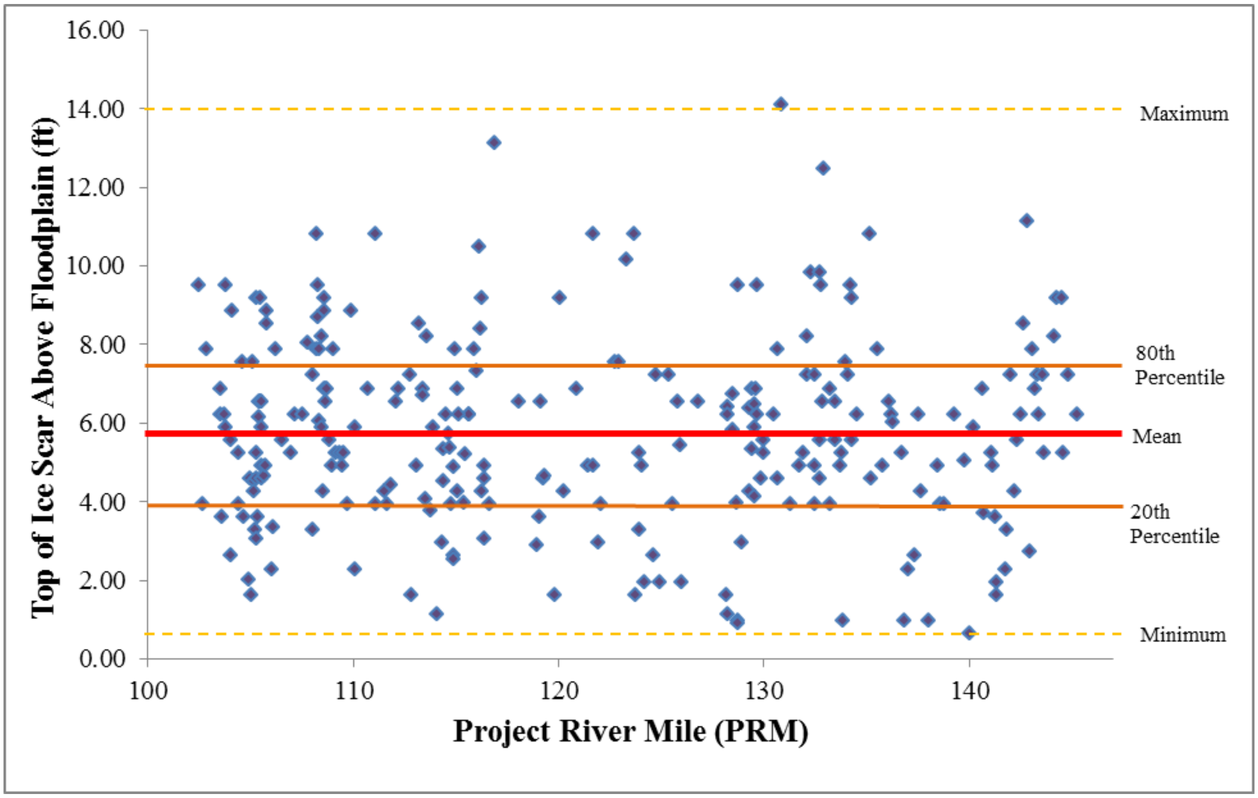


Figure 5.4-1. Top of ice scar above floodplain height (in feet) for scar observations between PRM 102.2 and 145.8.

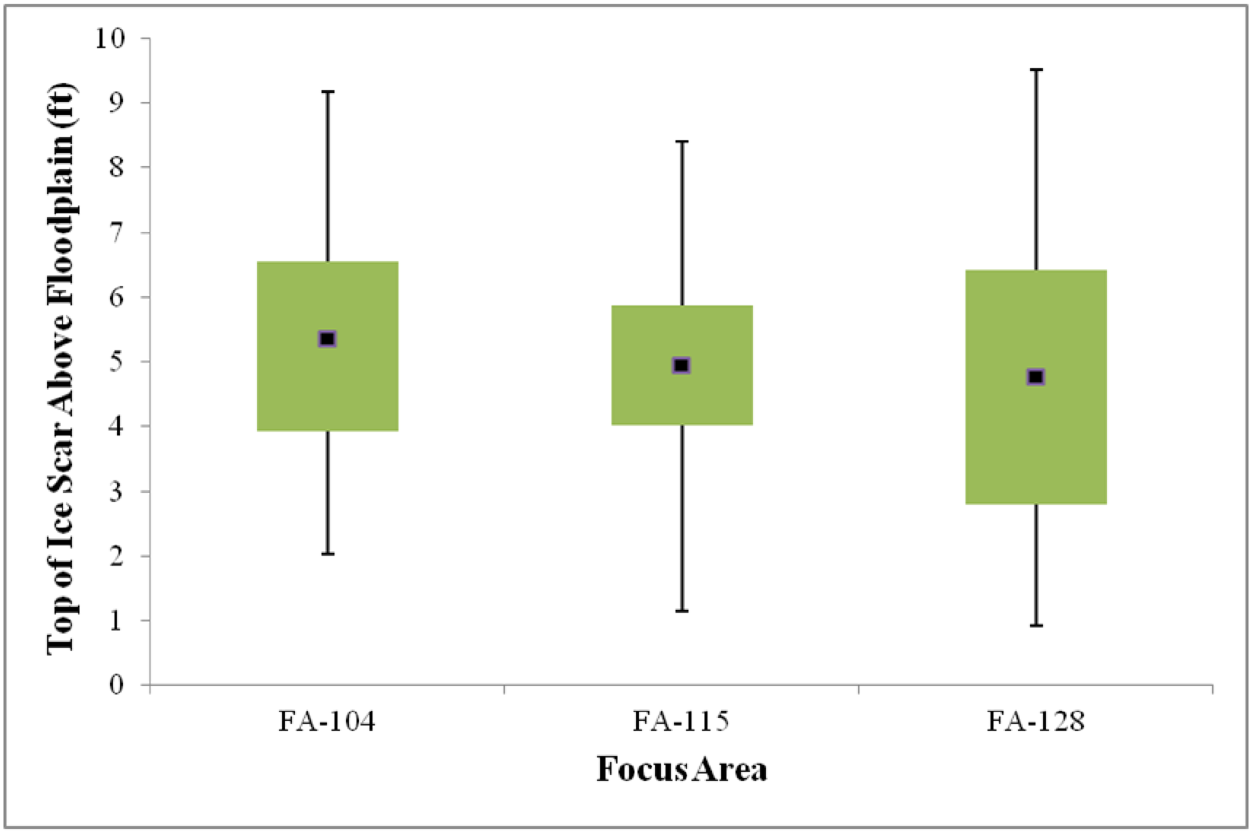
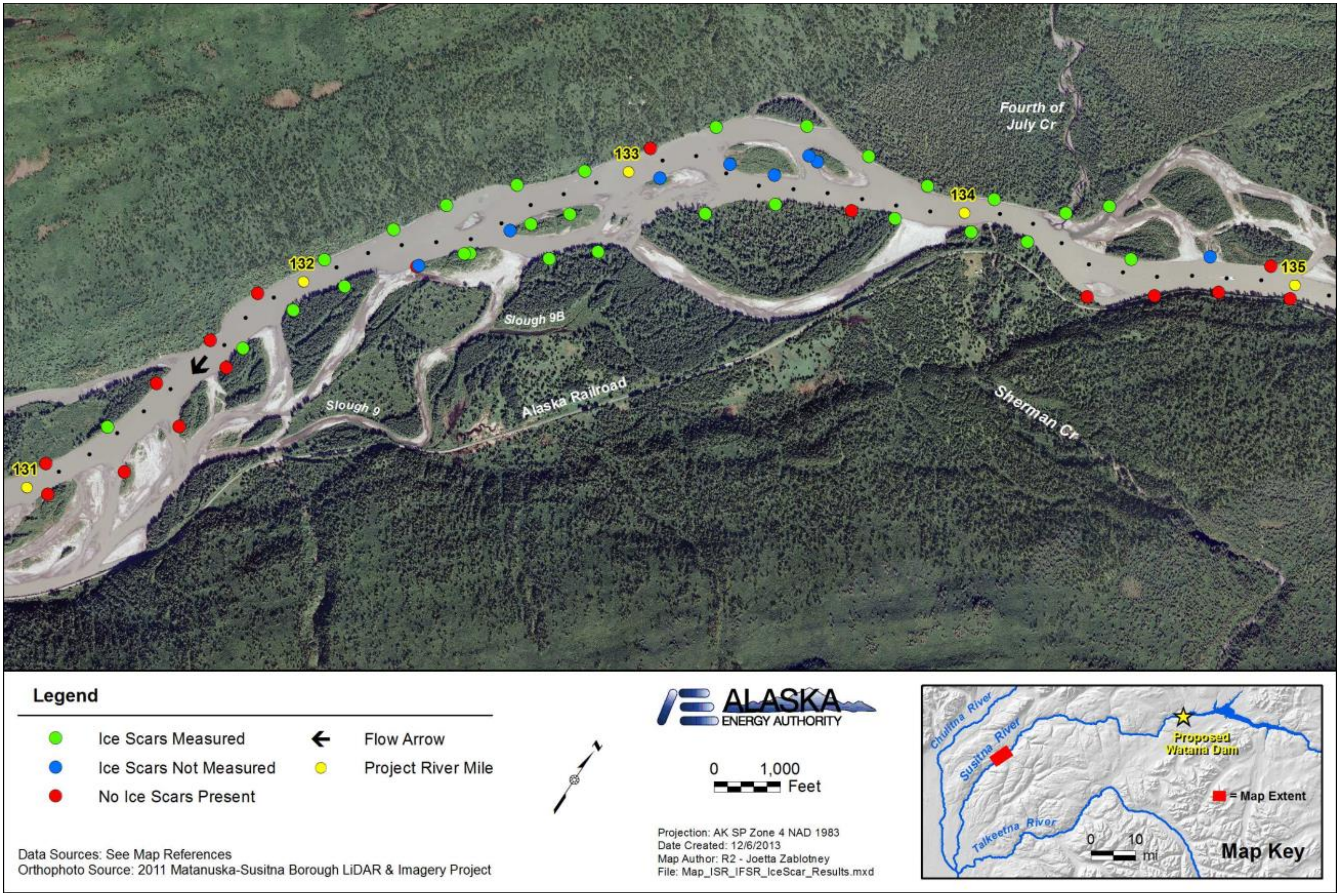


Figure 5.4-2. Box and whisker plots of top of ice scar heights (ft) above the floodplain surface at three focus areas. Black squares represent mean height.



Data Sources: See Map References
Orthophoto Source: 2011 Matanuska-Susitna Borough LiDAR & Imagery Project

Figure 5.4-3. Map of ice scar locations at a representative reach with frequent ice scars from PRM 132.1 to 135.0.

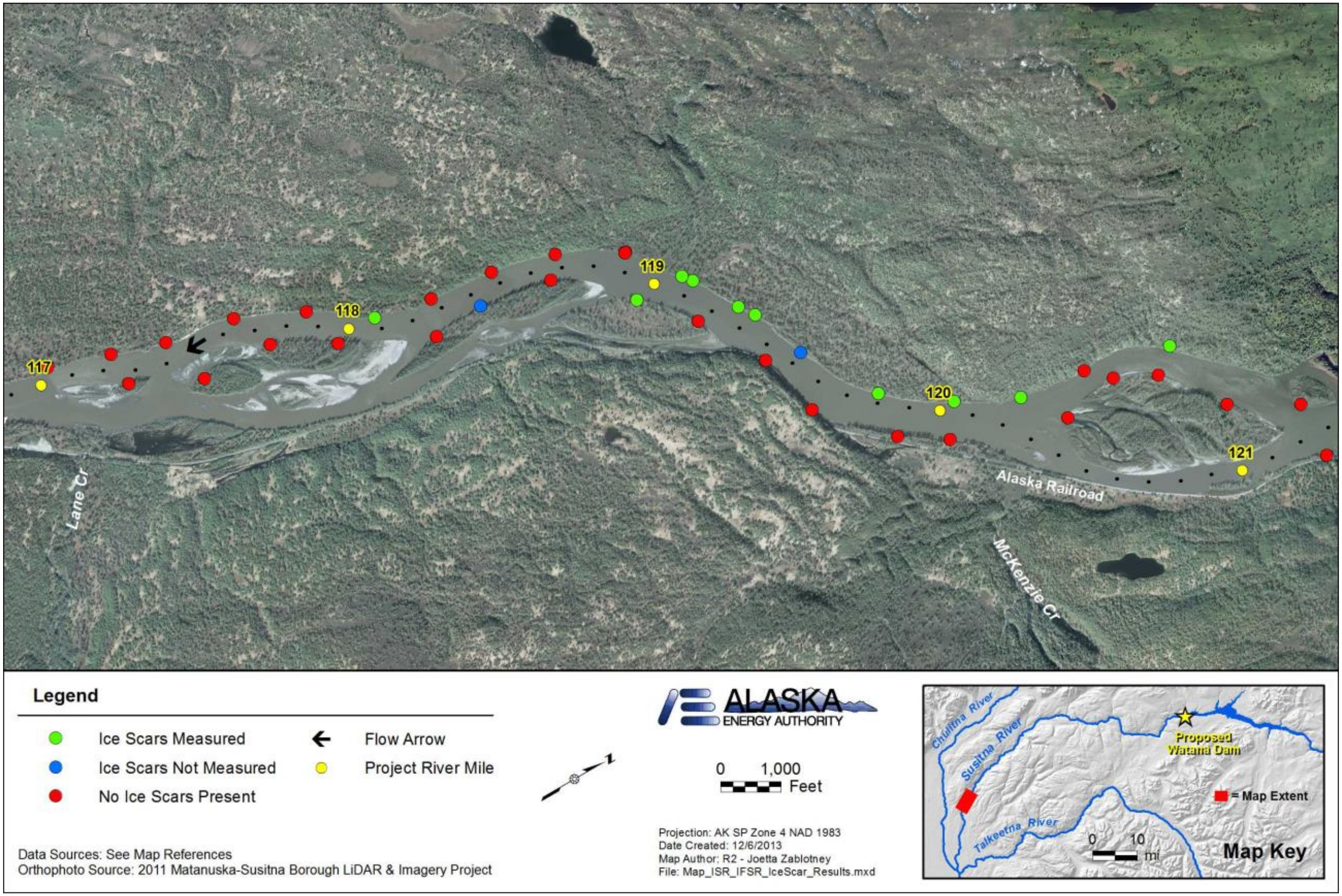
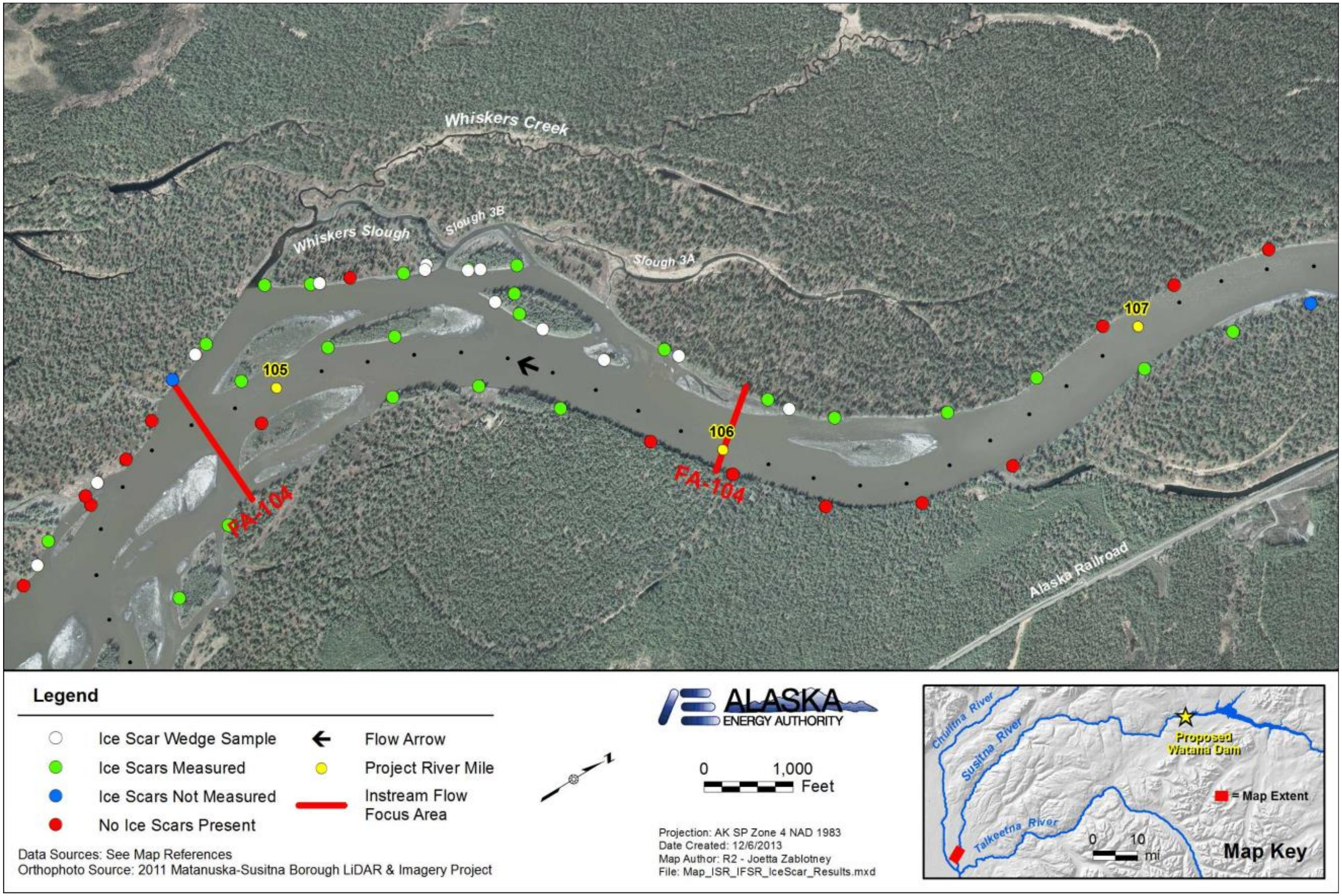


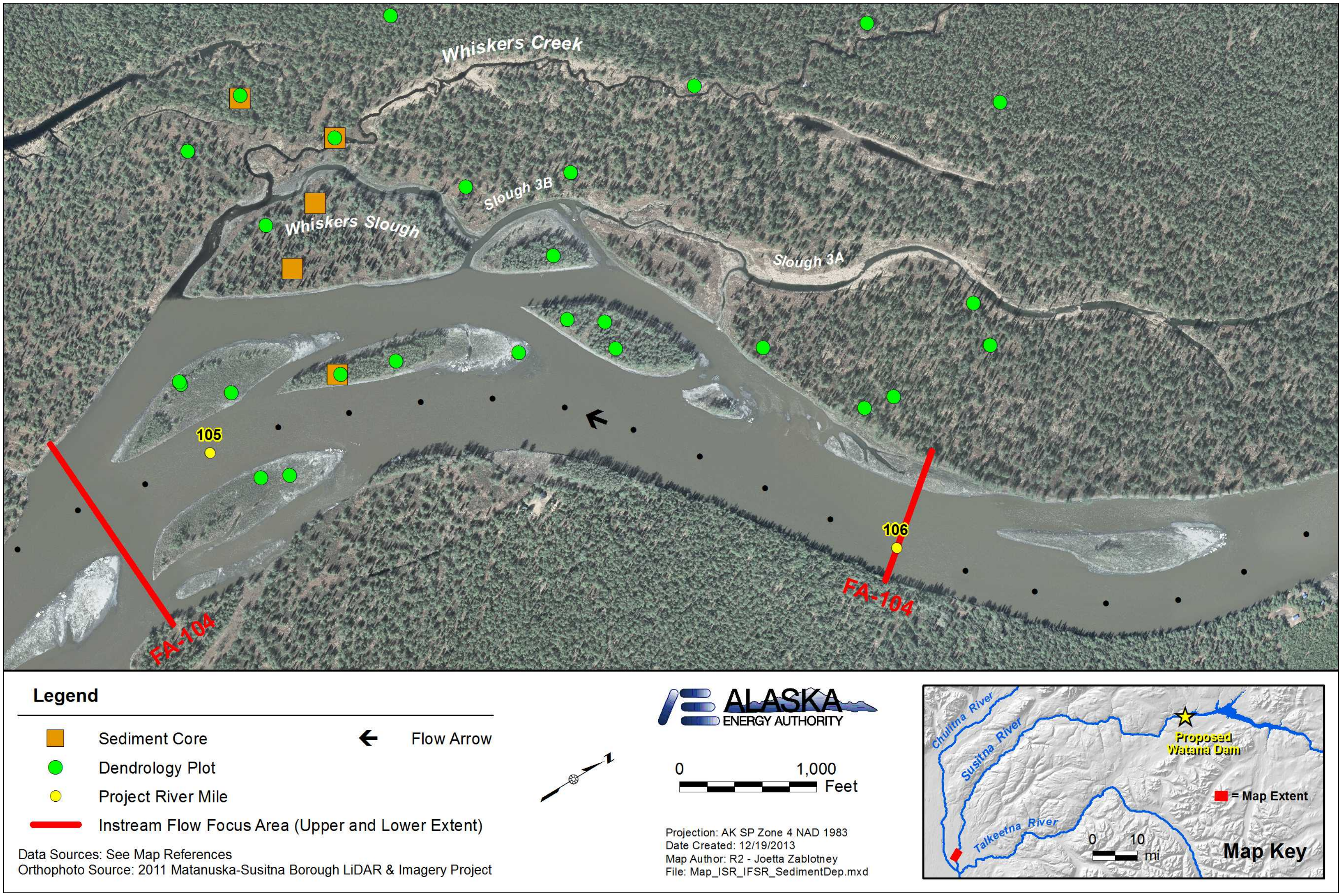
Figure 5.4-4. Map of ice scar locations at a representative reach with infrequent ice scars from PRM 116.9 to 121.3.



Data Sources: See Map References
Orthophoto Source: 2011 Matanuska-Susitna Borough LiDAR & Imagery Project

Projection: AK SP Zone 4 NAD 1983
Date Created: 12/6/2013
Map Author: R2 - Joetta Zablotney
File: Map_ISR_IFSR_IceScar_Results.mxd

Figure 5.4-5. Map of ice scar locations and sampled ice scar wedges at FA-104.



Data Sources: See Map References
Orthophoto Source: 2011 Matanuska-Susitna Borough LiDAR & Imagery Project

Projection: AK SP Zone 4 NAD 1983
Date Created: 12/19/2013
Map Author: R2 - Joetta Zablotney
File: Map_ISR_IFSR_SedimentDep.mxd

Figure 5.5-1. Sediment core sampling locations and Dendrology Plots surveyed at FA-104.

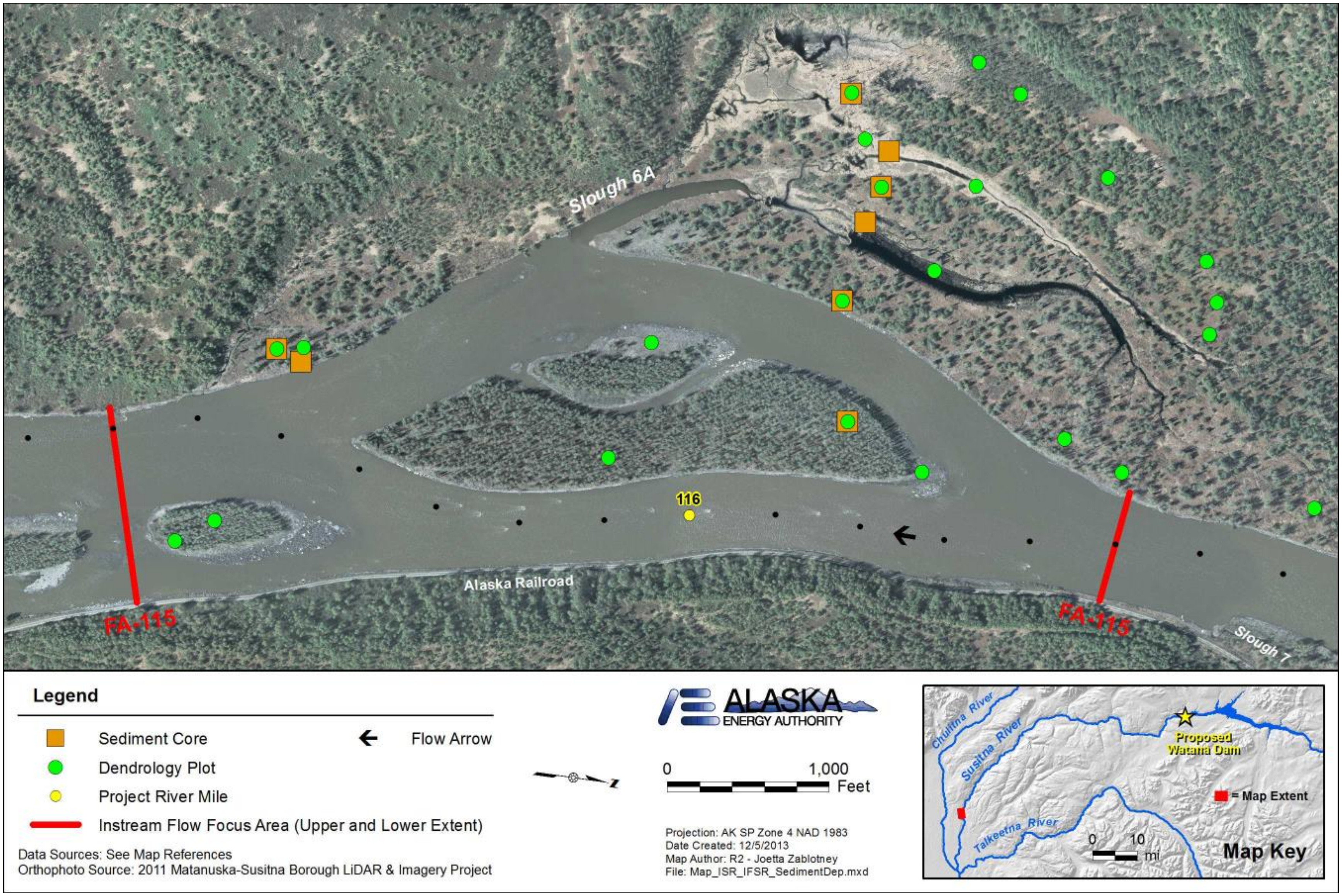


Figure 5.5-2. Sediment core sampling locations and Dendrology Plots surveyed at FA-115.

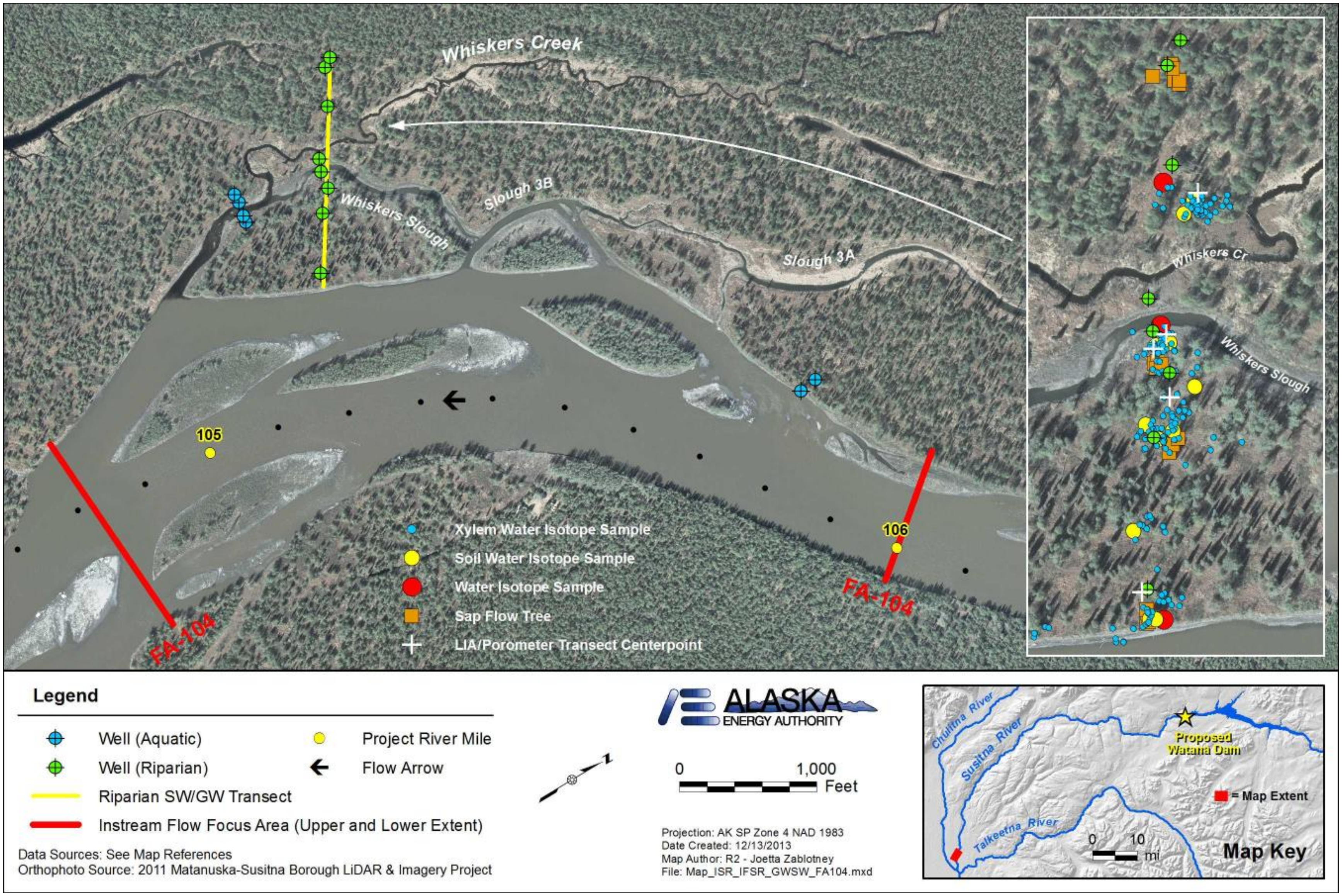


Figure 5.6-1. Riparian GW/SW sampling locations at FA-104.

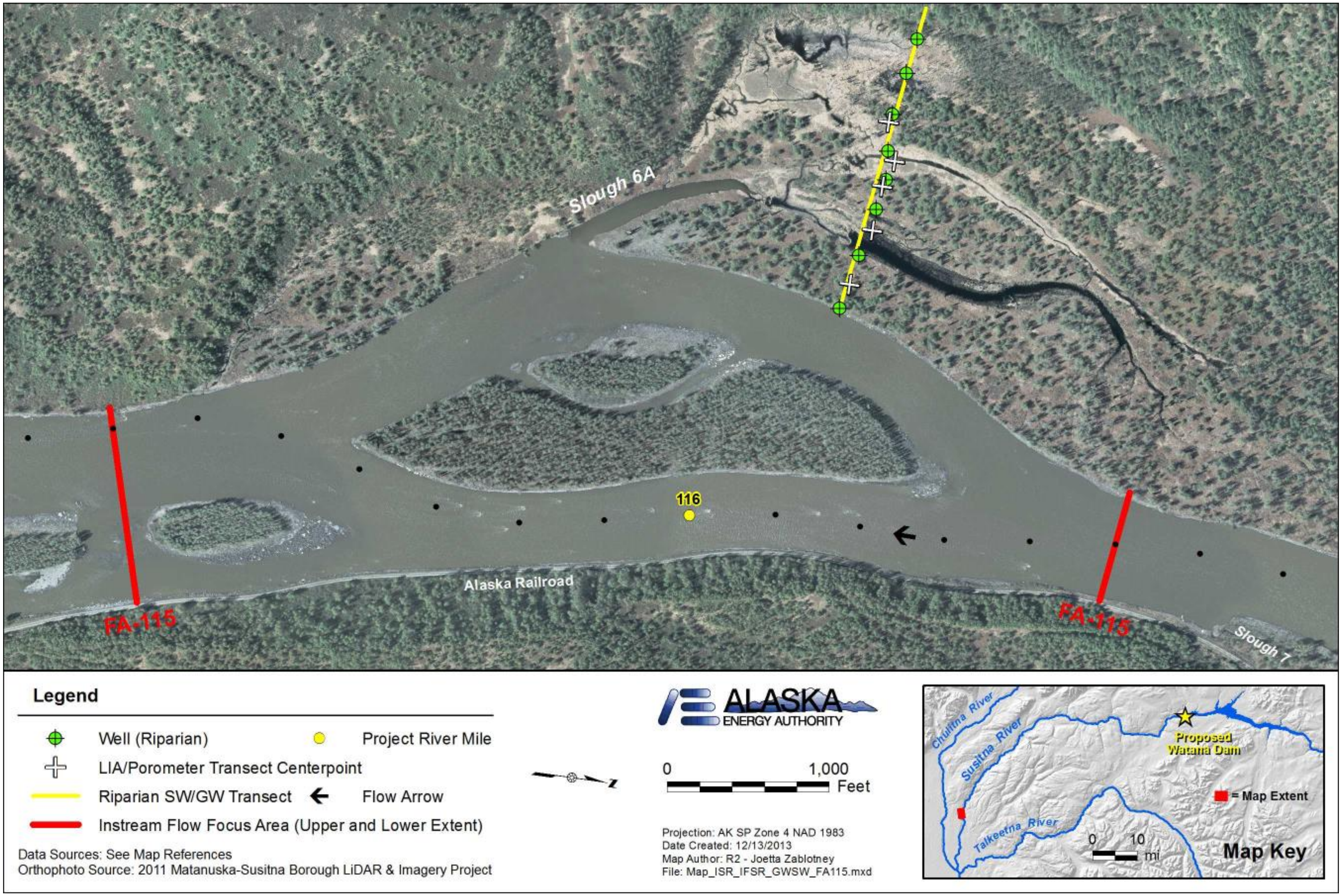


Figure 5.6-2. Riparian GW/SW sampling locations at FA-115.

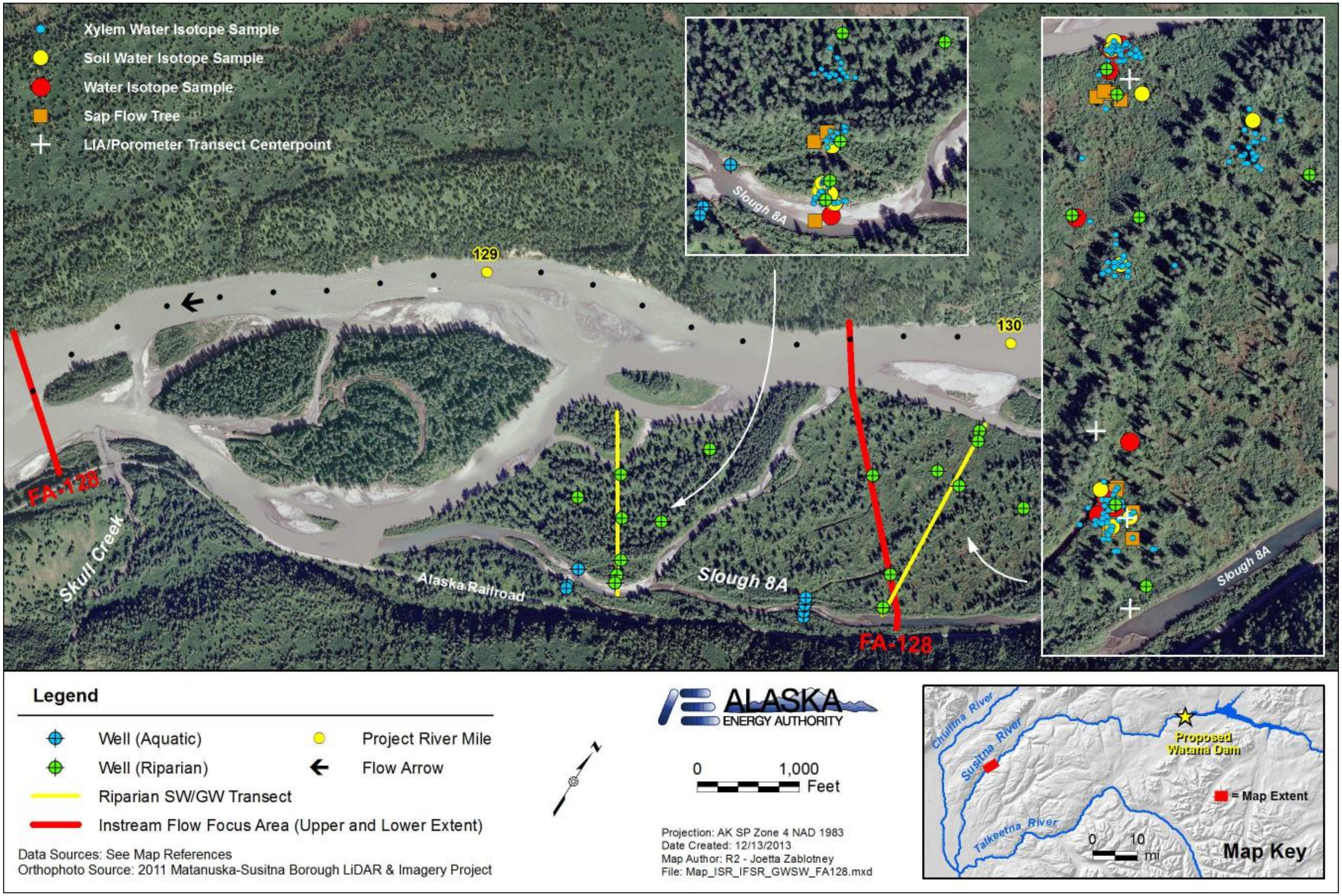
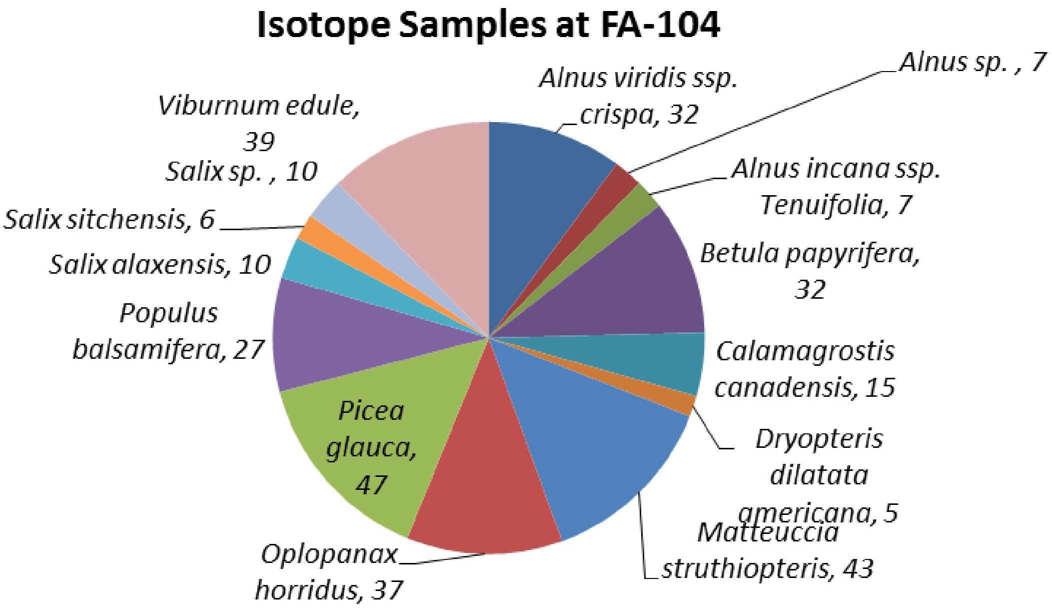


Figure 5.6-3. Riparian GW/SW sampling locations at FA-128.



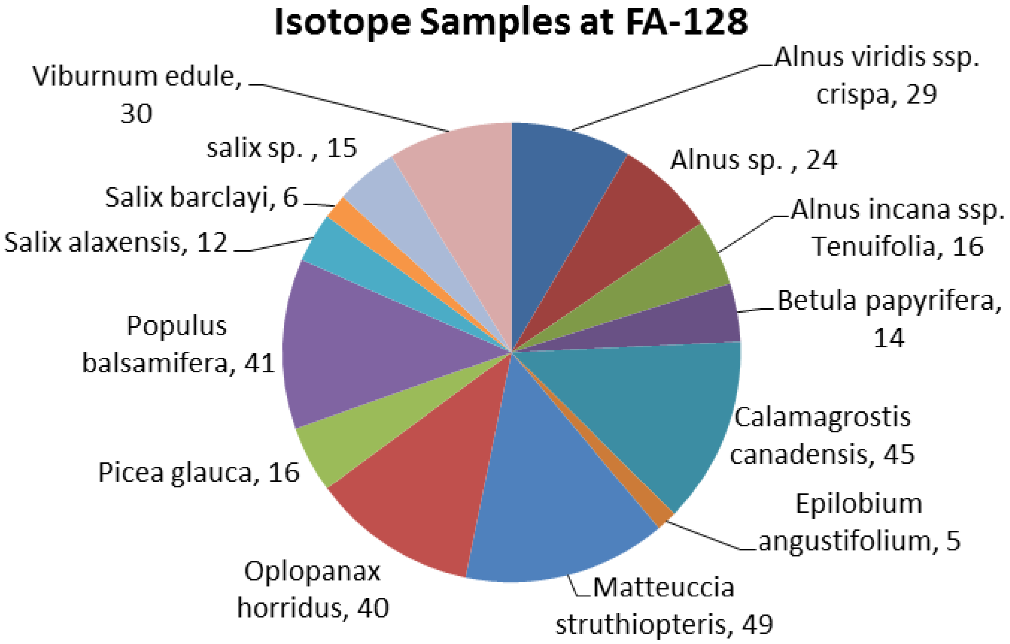


Figure 5.6-4. Distribution of Plant Isotope Samples by Plant Species at FA-104 and FA-128.

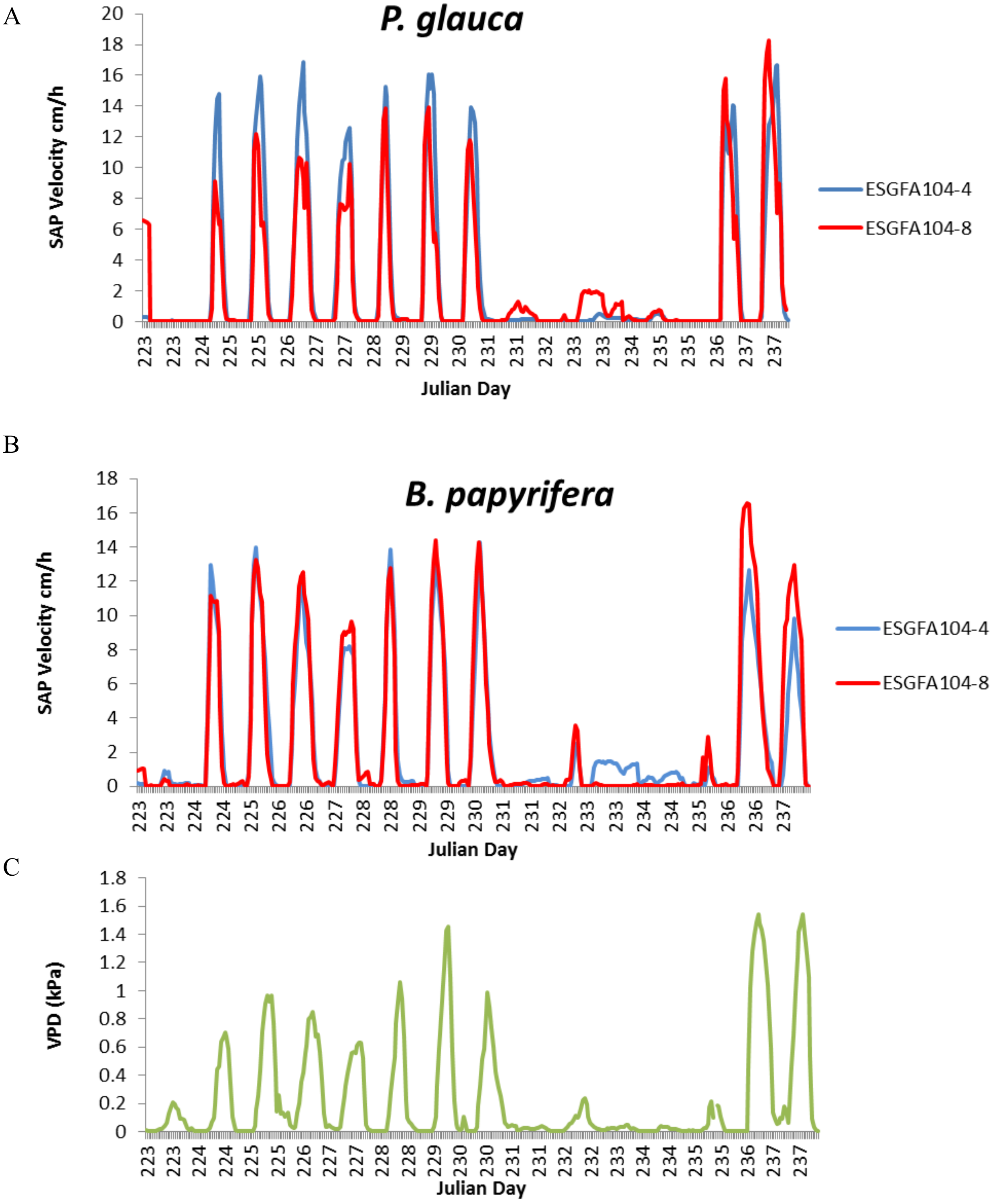


Figure 5.6-5. Sample data for sap velocity at two representative floodplain sampling locations at FA-104 between August 11, 2013 and August 27, 2013 (Julian day 223-237) for (A) *P. glauca* and (B) *B. papyrifera* and (C) vapor pressure deficit during this sample period.

Note: Data at other sites and for remainder of season is in QC3 process and will be available for further analysis.

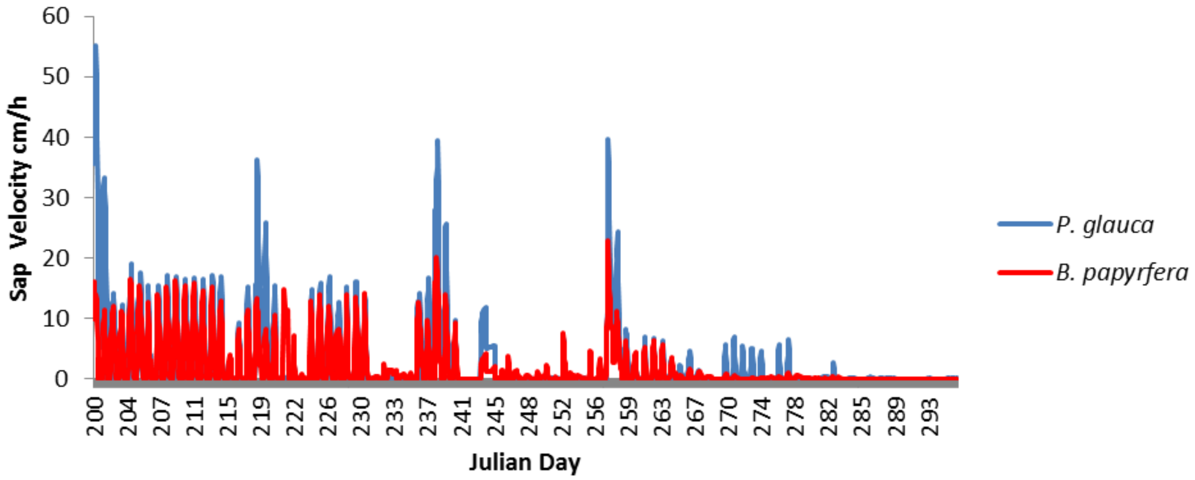
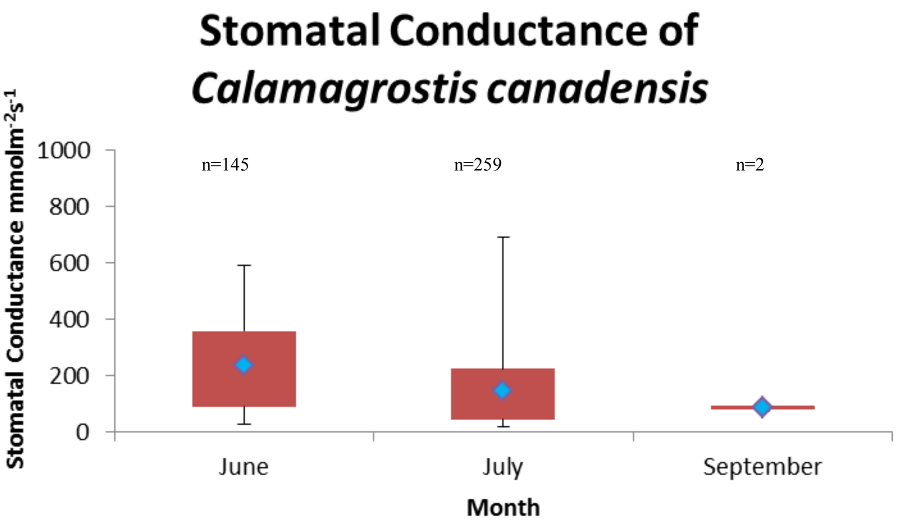


Figure 5.6-6. Sap velocity for representative *P. glauca* and *B. papyrifera* trees at Station ESAFA104-4.

Note: Data at other trees and sites and for remainder of season is in QC3 process and will be available for analysis.

(a)



(b)

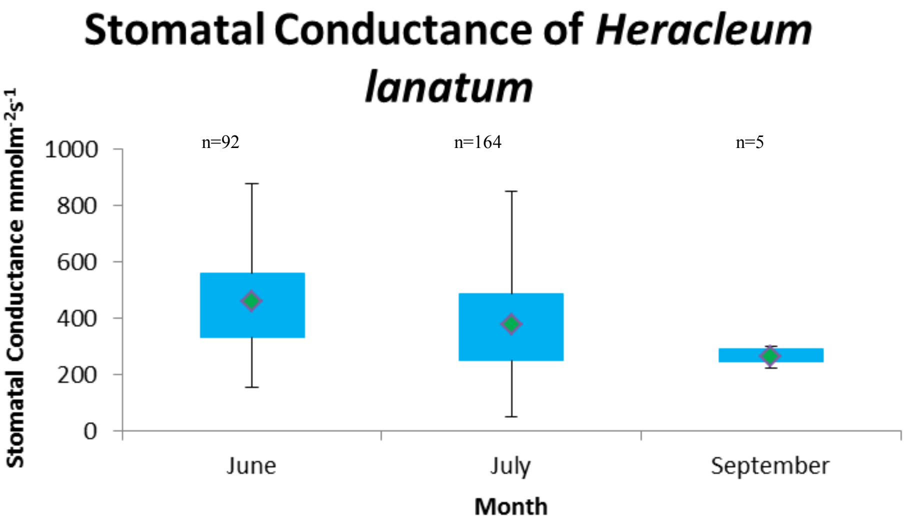
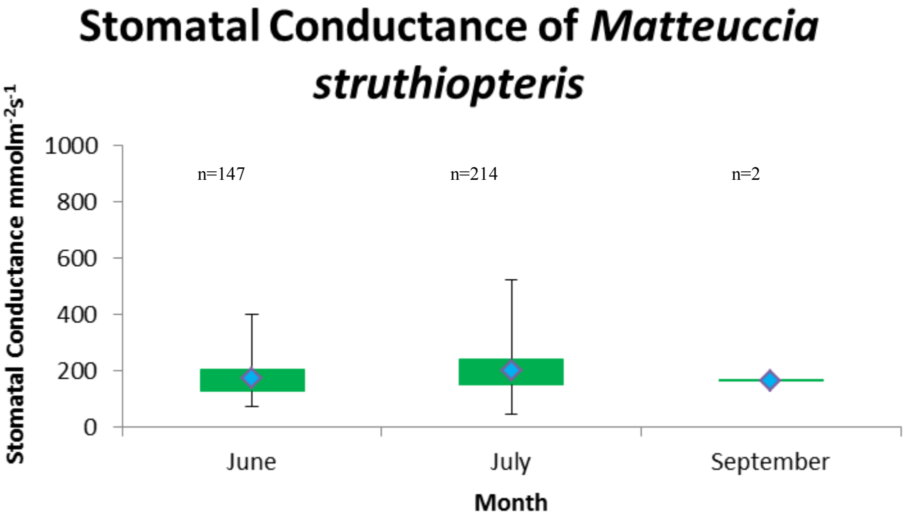


Figure 5.6-7. Seasonal Stomatal Conductance Distribution by Selected Species for (a) *C. canadensis* and (b) *H. lanatum*.

Boxes represent the upper and lower quartile of samples, whiskers of the boxes represents the IQR (interquartile range) or values in the data that are furthers way from the median on either side of the box, and the mean is represented by a diamond.

(a)



(b)

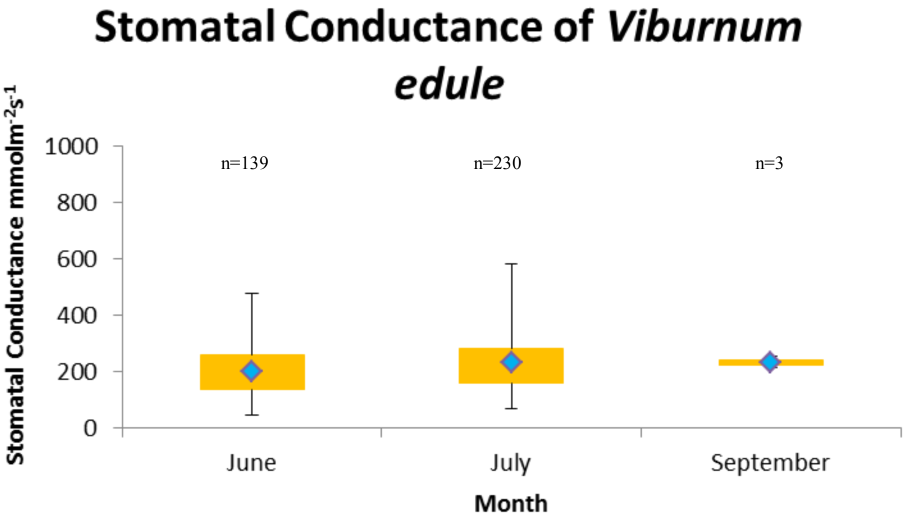
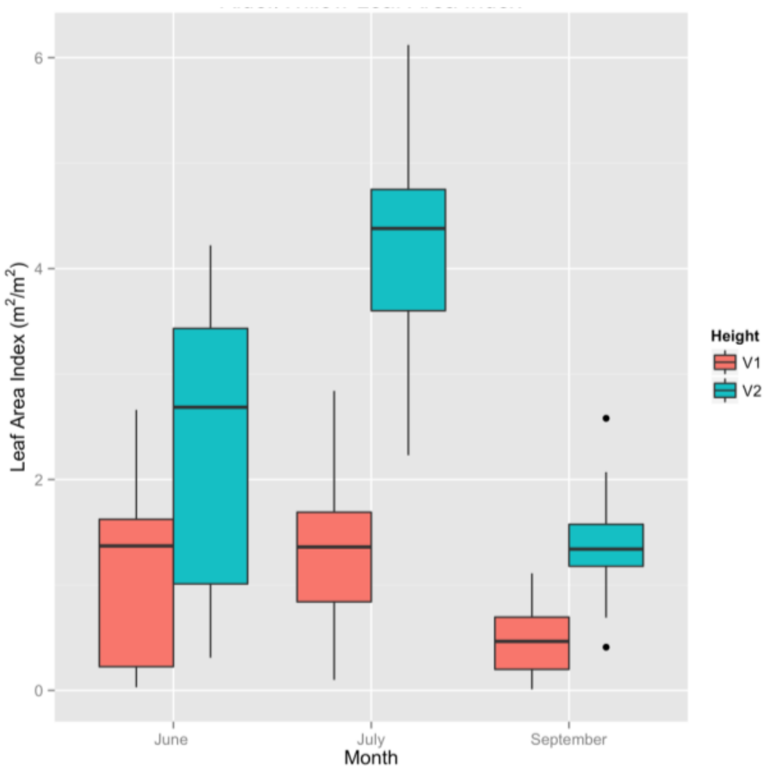


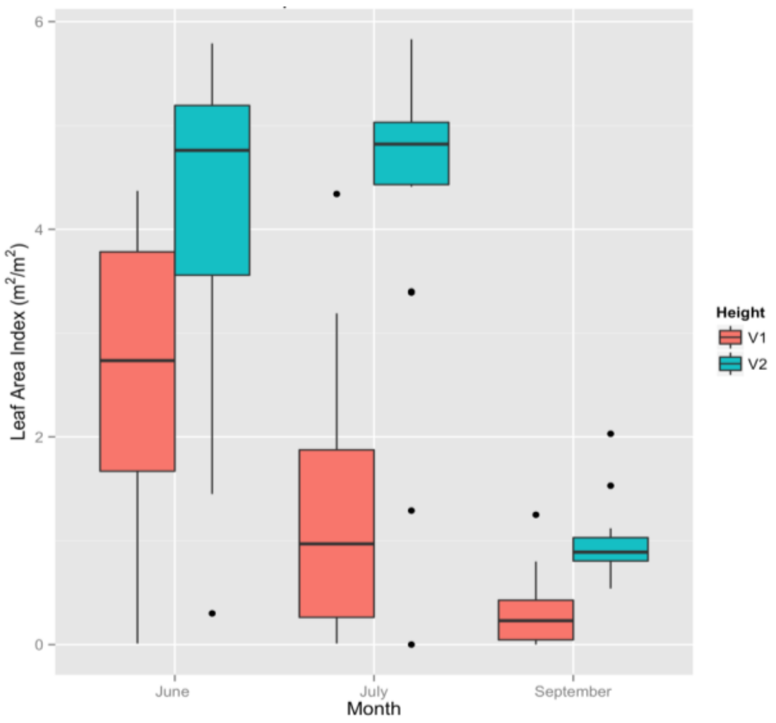
Figure 5.6-8. Seasonal Stomatal Conductance Distribution by Selected Species for (a) *M. struthiopteris*, and (b) *V. edule*.

Boxes represent the upper and lower quartile of samples, whiskers of the boxes represents the IQR (interquartile range) or values in the data that are furthers way from the median on either side of the box, and the mean is represented by a diamond.

(a) Alder/willow canopy type Leaf Area Index



(b) Poplar Canopy Leaf Area Index



(c) Spruce/Birch Canopy Leaf Area Index

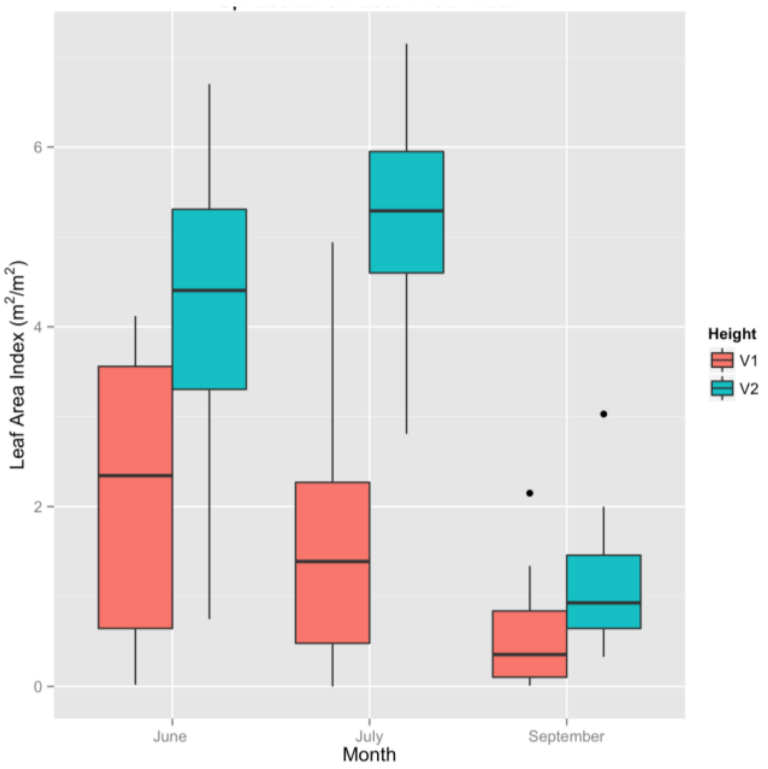


Figure 5.6-9. Seasonal Leaf Area Index (LAI) by Canopy Types for (a) Alder/Willow, (b) Poplar, and (c) Spruce/Birch.

Boxes represent the upper and lower quartile of samples, whiskers of the boxes represents the IQR (interquartile range) or values in the data that are furthers way from the median on either side of the box, and dots represent outliers to the dataset. Height is the vertical distance off the ground the measurement was taken (e.g., V1 = 150 cm from ground surface, V2 = 5 cm from ground surface).

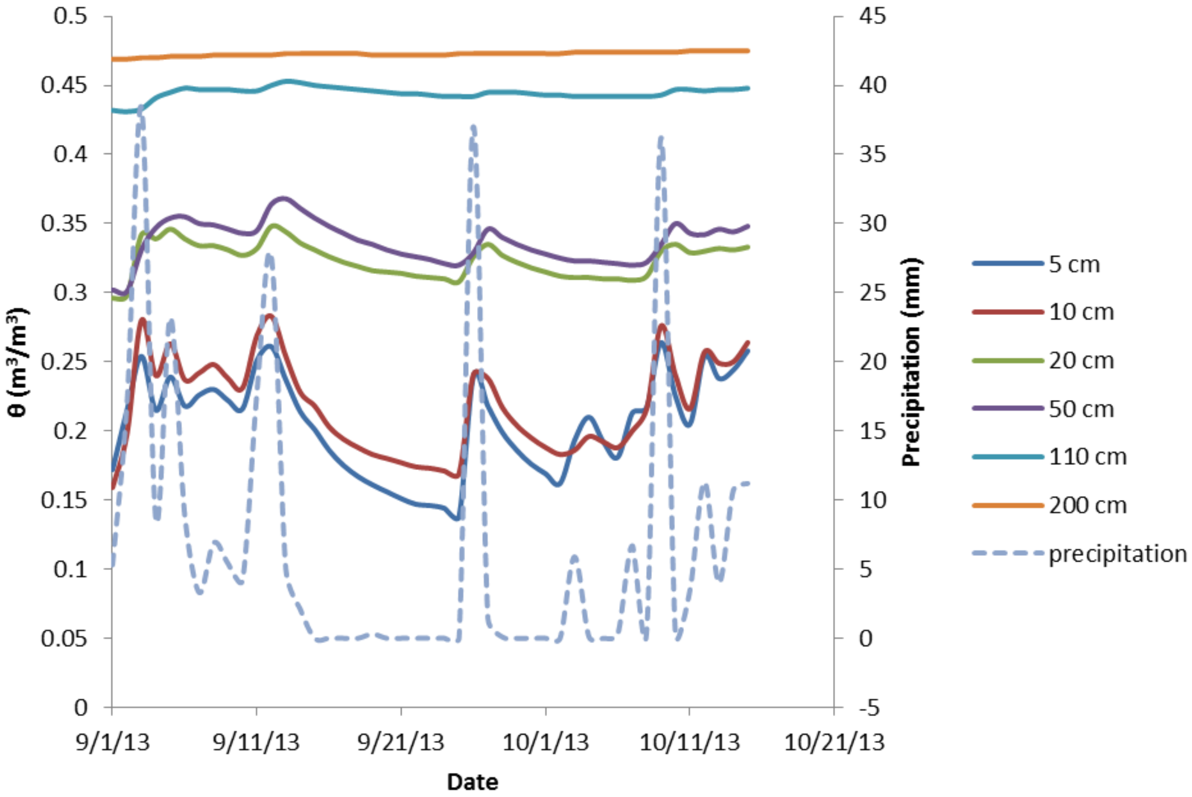


Figure 5.6-10. Soil Volumetric Water Content (θ) measured at FA-104 at depths ranging from 5 to 200 cm.

APPENDIX A: RIPARIAN FOCUS AREA SELECTION: RESPONSE TO AGENCY COMMENTS REGARDING HERBACEOUS VEGETATION

Riparian Focus Area Selection

Response to agency comments regarding Herbaceous Vegetation

Prepared by: Aaron Wells, Kevin Fetherston, and Kate Knox

Introduction

Aaron Wells (ABR, Inc. — Environmental Research & Services) and Kevin Fetherston, Kate Knox and Alice Shelly (R2 Resource Consultants) joined in a conference call on 21 February 2013 with Bob Henszey, U.S. Fish and Wildlife Service (USFWS), and Chiska Derr, National Oceanic and Atmospheric Administration (NOAA), to discuss final Riparian IFS vegetation sampling approach, including focus area (FA) selection in the Middle River and 2013 Lower River riparian vegetation sampling. During the meeting ABR and R2 described the methods for classifying the Riparian Process Domains (RPDs), and for mapping vegetation along the Middle River using both Integrated Terrain Unit (ITU) mapping and vegetation transects. The results of the classification and mapping were presented and discussion centered on the selection of FAs and the degree which the selected FAs were representative of each of the RPDs. During which both USFWS and NOAA generally agreed with the approach to classifying the Middle River and FAs selection (Figure 1); however, the meeting adjourned with USFWS and NOAA agreeing to hold a conference call to discuss the focus area selection strategy and provide a formal response, including any additional concerns. In an email response dated 22 February 2013 USFWS and NOAA raised concerns about the adequacy of the riparian FAs in representing the herbaceous vegetation along the Middle River. This technical brief was prepared in response to these concerns.

Methods

The vegetation transects and Integrated Terrain Unit vegetation mapping were used to determine the adequacy of herbaceous vegetation sampling in the Middle River FAs. The total length of transects typed as the Level I vegetation class "herbaceous" were summed by RPD and FA to determine the RPDs that feature a relatively large portion of the area as herbaceous vegetation. These results were used to determine that the remaining mapping and analyses be restricted to RPD 3 as this is the longest and most complex RPD and has the greatest coverage of herbaceous vegetation types (see RESULTS, below).

In the section of RPD 3 covered by ITU mapping (PRM 118–145), the area of Level IV herbaceous vegetation types (Viereck et al. 1992) types was calculated across each RPD, and within each of the proposed focus areas. These results were used to 1) determine how well the focus areas represented the herbaceous vegetation within each RPD, and 2) to select additional areas outside the focus areas (satellite areas) in which to sample herbaceous vegetation, thus increasing sample plot number for herbaceous vegetation in RPDs where the Focus Areas may be underrepresented.

For those areas of RPD 3 not covered by the ITU mapping, the portions of the vegetation transects classified as the Level I Viereck et al. (1992) vegetation class "herbaceous" were reclassified at the Level II Viereck et al. (1992) level (e.g., Forb Herbaceous, Graminoid Herbaceous). The lengths of the transect segments mapped as a Level II herbaceous class were aggregated by RPD and respective FA. The results were used to determine the representativeness of the herbaceous vegetation in each FA relative to the RPD and to select additional satellite sampling areas outside of the FAs if necessary.

Results and discussion

RPD 3 (4,138 m) featured the greatest cumulative distance of vegetation transects classified as herbaceous (Figure 2). In RPD 3, Gold Creek (235 m, 6 percent of the total), Lane Creek (183 m, 4 percent), and Skull Creek/Slough 8a (21 m, 1 percent) were the only FAs featuring herbaceous vegetation. Given the low abundance of herbaceous vegetation in the RPD3 FAs relative to the total abundance across the entire FA we further assessed the herbaceous vegetation in RPD 3 (see below). RPD 4 (2,198 m) featured the second highest cumulative distance of vegetation transects classified as herbaceous. In RPD4, Whiskers Slough featured a cumulative length of 770 m (35 percent of the total) of herbaceous vegetation. Given the high abundance of herbaceous vegetation in the Whiskers Slough FA relative to the total abundance across the entire focus area we conclude that the herbaceous vegetation in Whiskers Slough adequate represents RPD4.

The current extent of ITU mapping falls entirely within RPD3. Four Level IV vegetation classes were mapped in this section of river in 2012 (Figure 2), including Ferns (56 acres), large umbel (30), wet forb meadow (27), and bluejoint meadow (4). Three FAs were covered by the ITU mapping, including FA-141 (Indian River), FA-138 (Gold Creek), and FA-128 (Skull Creek). Herbaceous vegetation was not mapped at FA-141 and FA-128 (Figure 3). Three Level IV herbaceous vegetation types were mapped at FA-138, including Ferns (8 acres), Large Umbel (6), and Wet Forb Meadow (10). In areas of RPD3 covered by ITU mapping, the low coverage of herbaceous vegetation types in several of the FAs suggests that FA-138 (Gold Creek) be included as a riparian focus area in RPD 3. Additionally, several satellite areas where herbaceous vegetation is abundant, including between PRM 112–113, 125–127, and 132–133, will be incorporated into the 2013 sampling scheme.

In those areas of RPD 3 not currently covered by ITU mapping, including downstream of PRM 118 and upstream of PRM 145, a total of 2,266 m were mapped as Level II herbaceous. Of the total length, 1,196 m (53 percent of the total) were mapped as Forb Herbaceous, while 1,070 m (47 percent) were mapped as Graminoid Herbaceous (Figure 4). No herbaceous vegetation types were mapped at FA-144 (Side Channel 21). A total of 184 m of Level II herbaceous types were mapped at FA-115 (Lane Creek), including both Forb Herbaceous (114 m, 62 percent of the total) and Graminoid Herbaceous (70 m, 38 percent). Hence, the herbaceous vegetation at FA-115 featured a similar proportion of Level II vegetation classes and thus adequately represents RPD 3 in areas not currently covered by ITU mapping.

Literature Cited

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick. 1992. The Alaska Vegetation Classification. Pacific Northwest Research Station, U.S. Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR-286. 278 pp.

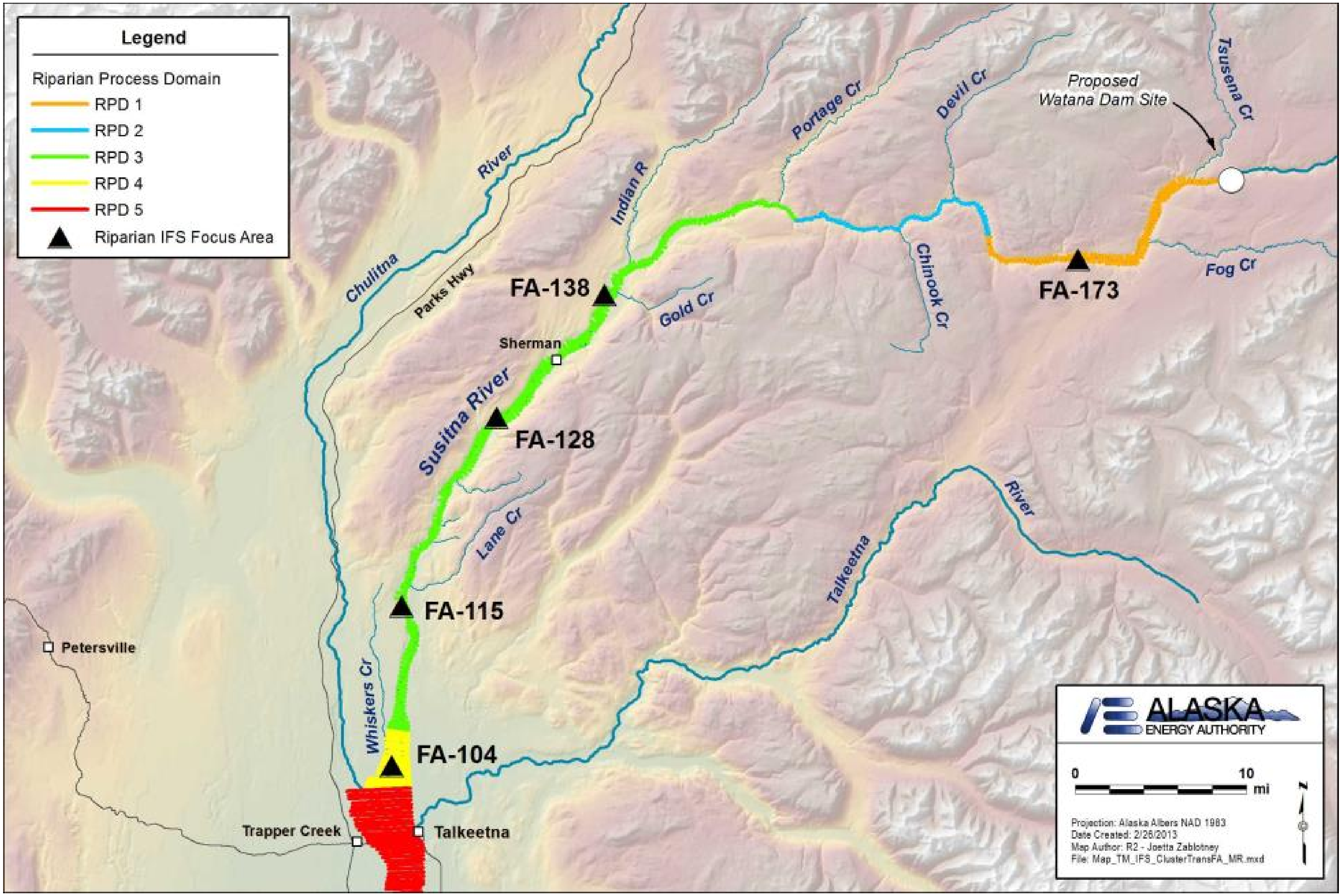


Figure 1. Middle River Riparian Process Domains and Focus Areas.

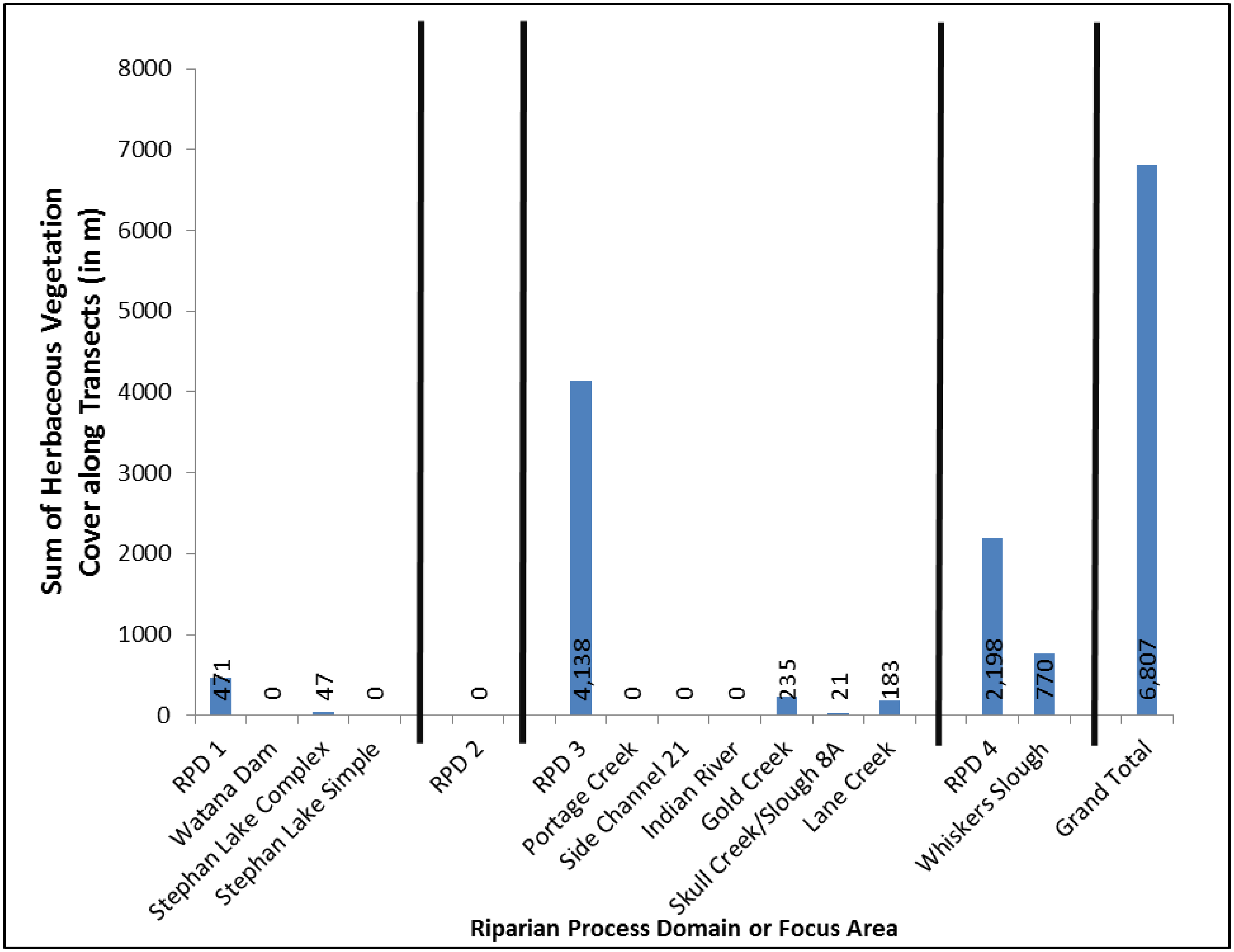


Figure 2. Length of transects typed as herbaceous vegetation within Riparian Process Domains 1-4 compared with herbaceous vegetation typed along transects within the Focus Areas associated with each RPD. Lengths are in meters.

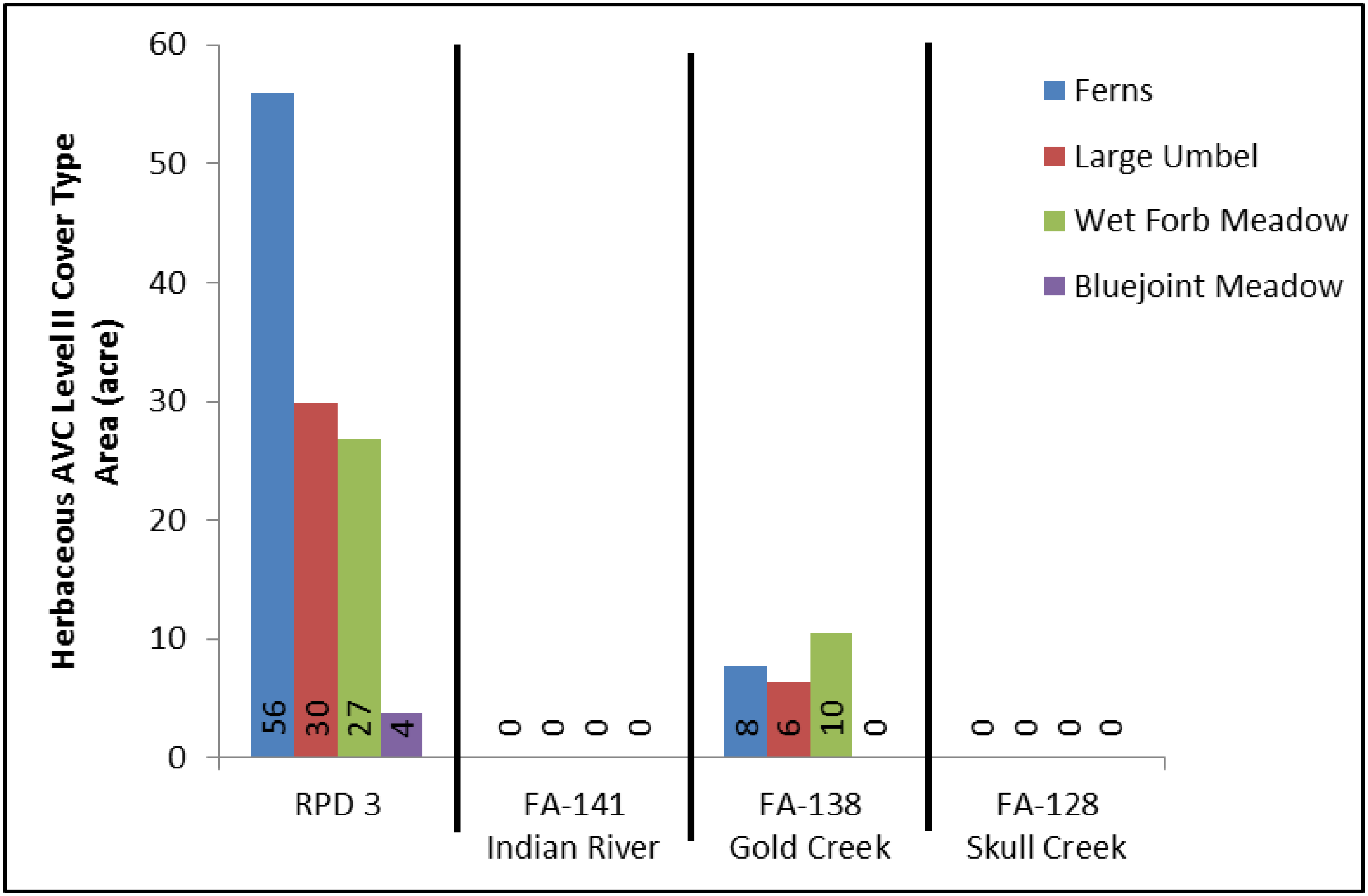


Figure 3. Area (ac) of Herbaceous AVC Level II Cover Types in each of three Focus Areas relative to portion of RPD3 with completed Integrated Terrain Unit Mapping.

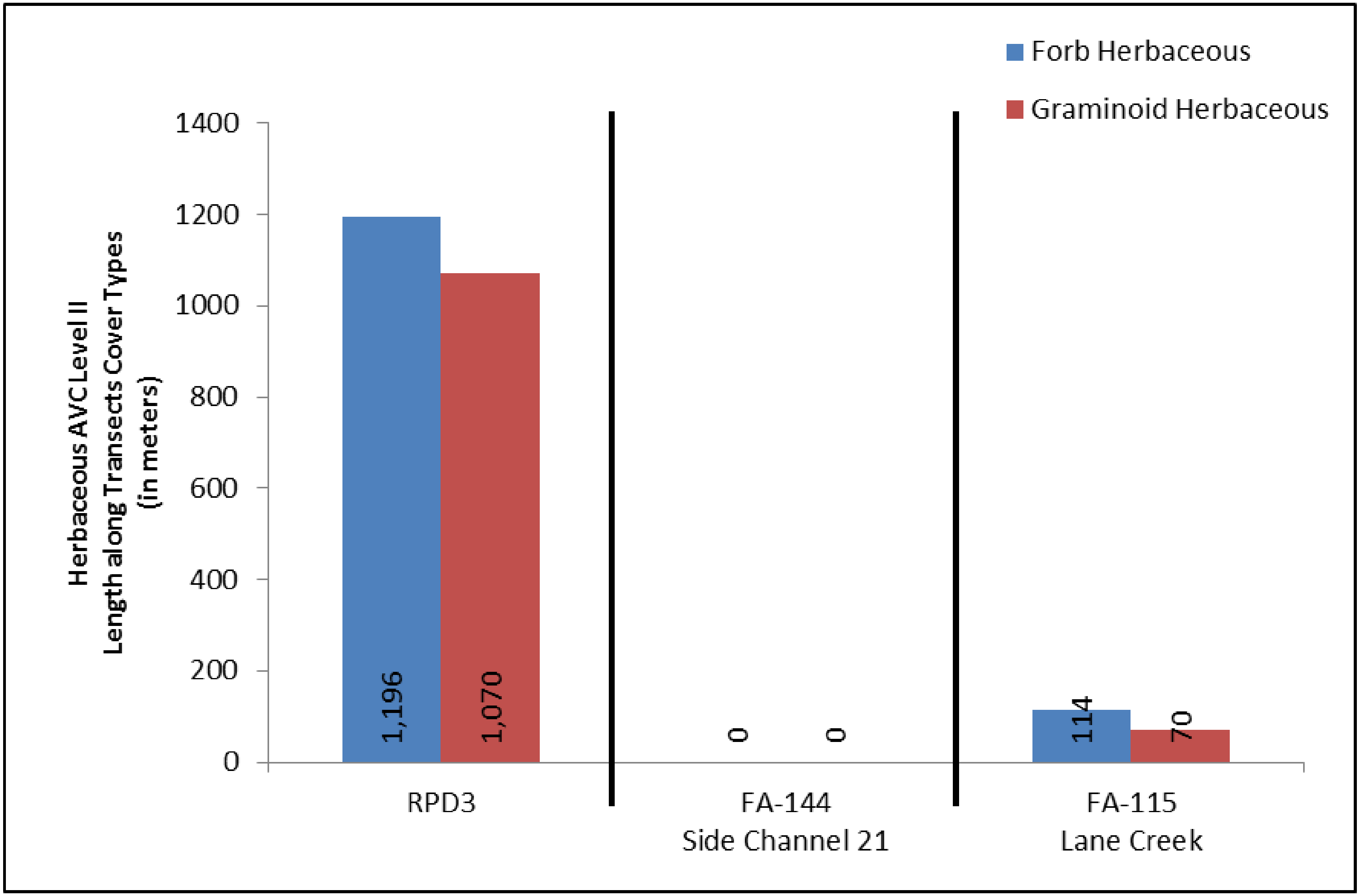


Figure 4. Sum of transect lengths (in meters) by cover type for Herbaceous AVC Level II for the part of RPD3 and Focus Areas without completed Integrated Terrain Unit Mapping.